2007

METEOROIDS

Barcelona, June 11-15

About the cover:

The recent fall of the Villalbeto de la Peña meteorite on January 4, 2004 (Spain) is one of the best documented in history for which atmospheric and orbital trajectory, strewn field area, and recovery circumstances have been described in detail. Photometric and seismic measurements together with radioisotopic analysis of several recovered specimens suggest an original mass of about 760 kg. About fifty specimens were recovered from a strewn field of nearly 100 km^2. Villalbeto de la Peña is a moderately shocked (S4) equilibrated ordinary chondrite (L6) with a cosmic-ray-exposure age of 48±5 Ma. The chemistry and mineralogy of this genuine meteorite has been characterized in detail by bulk chemical analysis, electron microprobe, electron microscopy, magnetism, porosimetry, X-ray diffraction, infrared, Raman, and ^{57}Mössbauer spectroscopies.

The picture of the fireball was taken by M.M. Ruiz and was awarded by the contest organized by the Spanish Fireball Network (SPMN) for the best photograph of the event. The Moon is also visible for comparison. The picture of the meteorite was taken as it was found by the SPMN recovery team few days after the fall.

FINAL PROGRAM

Monday, June 11

Auditorium conference room

9h00-9h50	Reception

9h50-10h00	Opening event

Session 1: Observational Techniques and Meteor Detection Programs

Morning session

Session chairs: J. Borovicka and W. Edwards

10h00-10h30	Pavel Spurny (Ondrejov Observatory, Czech Republic) et al. "Fireball observations in Central Europe and Western Australia – instruments, methods and results" (invited)
10h30-10h45	Josep M. Trigo-Rodríguez (Institute of Space Sciences IEEC-CSIC, Spain) et al. "Determination of meteoroid orbits and spatial fluxes by using high-resolution all-sky CCD cameras"
10h45-11h00	Prakash Atreya and Apostolos Christou (Armagh Observatory, Ireland) "The Armagh Observatory meteor camera cluster: overview and status"

11h00-11h30	Coffee break

11h30-12h00	Douglas O. ReVelle (Los Alamos National Laboratory, USA) "Acoustic-Gravity Waves from Bolide Sources" (invited)
12h00-12h15	Douglas O. ReVelle (Los Alamos National Laboratory, USA) et al. "Reanalysis of the Large Bolide Microbarograph Data"
12h15-12h30	Wayne Edwards (Univ. of Western Ontario, Canada) "Infrasonic observations of meteoroids: Preliminary results from the coordinated optical-radar-infrasound observing campaign at SOMN"
12h30-12h45	José Chilo (Royal Institute of Technology, Sweden) et al. "Meteorite's signal characterization and classification using Machine Learning Algorithms"
12h45-13h00	Pavlo Kozak (National Taras Shevchenko Univ., Ukraine) "Falling Star: software for complete processing of double-station TV observations of meteors"

Afternoon session

Session chairs: J. Watanabe and I. Williams

15h00-15h30	Diego Janches (NorthWest Research Associates/CoRA Division) "Meteor Head-Echo Observations Using High Power and Large Aperture Radar: A Review of Recent Results" (invited)
15h30-15h45	Peter G. Brown (Univ. of Western Ontario, Canada) et al. "The Southern Ontario Meteor Network (SOMN) – Overview of Sensors, Analysis Techniques and Status"
15h45-16h00	Robert J. Weryk (Univ. of Western Ontario, Canada) et al. "Comparisons of simultaneously detected radar and electro-optical meteors"
16h00-16h15	John D. Mathews (Pennsylvania State Univ., USA) et al. "Radio and meteor science outcomes from comparisons of meteor radar observations at AMISR Poker Flat, Sondrestrom, and Arecibo"
16h15-16h30	Akshay Malhotra (Pennsylvania State Univ., USA) et al. "A radio science perspective on Range-Spread Trail Echoes observed at Jicamarca"

16h30-17h00	Coffee break

Session 2: Meteor showers' activity and forecasting

Session chairs: R. Weryk and P. Spurný

17h00-17h30	Jeremie Vaubaillon and William Reach (California Institute of Technology, USA) "Infrared observation of meteoroid streams in the vicinity of cometary nuclei" (invited)
17h30-17h45	David J. Asher (Armagh Observatory, N. Ireland) "Meteor Outburst Profiles and Cometary Ejection Models"
17h45-18h00	Peter S. Gural (SAIC, USA) and Peter Jenniskens (SETI Institute, USA) "Spatial Flux Density Characterization during the 1999 Leonid Storm"
18h00-18h15	Apostolos A. Christou (Armagh Observatory, N. Ireland) et al. "Annual and outburst meteor activity in the atmospheres and Venus and Mars"
18h15-18h30	Michael Nolan et al. (Arecibo Observatory, Puerto Rico, USA) "Large grains ejected from 73P/Swassmann-Wachmann 3"
18h30-18h45	Peter Jenniskens (SETI Institute, USA) "The upcoming encounter with dust of a long-period comet: the 2007 Aurigid outburst"

18h45-20h00	Poster session

Tuesday, June 12

Auditorium conference room

Session 2: Meteor showers' activity and forecasting

Morning session

Session chairs: D. Asher and A. Christou

9h30-10h00	Junichi Watanabe (National Astronomical Observatory of Japan) "Activities of parent comets and related meteor showers" (invited)
10h00-10h15	Jurgen Rendtel (International Meteor Organization, Germany) "The Orionid meteor shower observed over 60 years"
10h15-10h30	Mikiya Sato and Junichi Watanabe (National Astronomical Observatory of Japan) "Origin of the outburst of Orionids 2006"
10h30-10h45	Pavel Koten (Ondrejov Observatory, Czech Republic) et al. "Video observations of the 2006 Leonid outburst"
10h45-11h00	Galina Ryabova (Tomsk State Univ., Russia) "Model radiants of the Geminid meteor shower"

11h00-11h30	Coffee break

11h30-12h00	Peter G. Brown (Univ. of Western Ontario, Canada) et al. "The Canadian Meteor Orbit Radar (CMOR) Meteor Shower Catalogue" (invited)
12h00-12h15	G. Yellaiah (Osmania Univ., India) "Perseid meteor shower observations by using Indian MST Radar"
12h15-12h30	Werner Singer (Leibniz Inst. of Atmospheric Physics, Germany) et al. "Influence of background dust on radar backscatter from meteor trails"
12h30-13h00	Special Talk: Maria E. Sansaturio and Óscar Arratia (Univ. Of Valladolid, Spain) "Apophis: the history behind the scenes" (invited)

Session 3: Orbits of meteoroids and dust

Afternoon session

Session chairs: J. Toth and J.M. Trigo-Rodríguez

15h00-15h30	Peter Jenniskens (SETI Inst., USA) "(Mostly) dormant comets in the NEO population that have meteoroid streams" (invited)
15h30-15h45	Giovanni Valsecchi (IASF-INAF, Italy) "The spreading of meteoroid streams induced by close planetary encounters"
15h45-16h00	Margaret Campbell-Brown (Univ. of Western Ontario, Canada)

	"Directional velocity distribution and flux variation of the sporadic meteoroid sources"
16h00-16h15	Tadeusz J. Jopek (Astronomical Observatory AM Univ., Poland) "Remarks on the mean orbits of the meteoroid streams"
16h15-16h30	Jonathan Mc Auliffe (ESA/ESTEC, The Netherlands) et al. "Meteoroid Orbit Determination: A need for consensus"

16h30-17h00	Coffee break

Session chairs: S. Abe and J. Vaubaillon

17h00-17h30	Paul Wiegert (Univ. of Western Ontario, Canada) "The dynamics of low-perihelion meteoroid streams" (invited)
17h30-17h45	Juraj Toth et al. (Comenius Univ. Bratislava, Slovak Republic) "Motion of a meteoroid released from an asteroid"
17h45-18h00	Leonard Komos and Juraj Toth (Comenius Univ. Bratislava, Slovak Republic) "Orbital evolution of Pribram and Neuschwanstein"

18h00-19h00	Poster session

19h00-20h00	CosmoCaixa Open Public Lecture: Clark R. Chapman "The Hazard of Asteroids and Comets Impacting Earth"

Wednesday, June 13

Auditorium conference room

Session 3: Orbits of meteoroids and dust (cont.)

Morning session

Session chairs: M. Campbell-Brown and D.O. ReVelle

9h30-10h00	Iwan Williams and D.C. Jones (Univ. of London, UK) "Meteorite streams: are they real?" (invited)
10h00-10h15	Shinsuke Abe (Kobe University, Japan) et al. "Orbit and spectroscopy of Earth-grazing meteoroid"
10h15-10h30	José M. Madiedo (Univ. Huelva, Spain) and Josep M. Trigo-Rodríguez (IEEC-CSIC, Spain) "Multi-station video observation of minor showers"
10h30-10h45	Csilla Szasz et al.(Swedish Inst. of Space Physics, Sweden) "Meteoroid orbit calculations from tristatic EISCAT UHF measurements"
10h45-11h00	Thomas Kehoe (Univ. of Florida, USA) "Dynamical evolution of asteroidal dust particles and their orbital element distribution in near-Earth space"

11h00-11h30	Coffee break

Session 4: Meteoroids interactions with atmospheres

Session chairs: J. Mc Auliffe and G. Valsecchi

11h30-12h00	Olga Popova (Inst. for Dynamic of Geospheres, Russia) "Models of meteoroid fragmentation" (invited)
12h00-12h15	Natalia G. Barri (Moscow State Univ., Russia) "Transverse scattering of meteoroid fragments in the atmosphere"
12h15-12h30	Tomas Vondrak (Univ. of Leeds, UK) et al. "Differential ablation of meteoroids a thermodynamic equilibrium model"
12h30-12h45	Jonathan T. Fentzke and Diego Janches (NorthWest Research Associates/CoRA Division) "A semi-empirical model of the contribution from sporadic meteoroid sources on the meteor input function observed at Arecibo"
12h45-13h00	Diego Janches and Jonathan T. Fentzke (NorthWest Research Associates/CoRA Division) "Estimating the meteoric mass flux in the Mesosphere and Lower Thermosphere Atmospheric region"

Afternoon session

Session chairs: D. Janches and O. Popova

15h00-15h30	Lars Dyrud et al. (Center for Remote Sensing Inc., USA) "Plasma and EM simulations of meteor head echo radar reflections" (invited)
15h30-15h45	Robert L. Hawkes et al. (Mount Allision Univ., Canada) "What can we learn about atmospheric meteor ablation and light production from laser ablation?
15h45-16h00	Johan Kero et al. (Swedish Inst. of Space Physics, Sweden) "Meteoroid disintegration characteristics in EISCAT HPLA radar observations"
16h00-16h15	Johan Kero et al. (Swedish Inst. of Space Physics, Sweden) "Three dimensional radar observation of a submillimeter meteoroid fragmentation"
16h15-16h30	Masa-yuki Yamamoto et al. (Kochi Univ. Of Technology, Japan) "Invisible persistent trains generated by Geminids"

16h30-17h00	Coffee break

Session chairs: F. Rietmeijer and J. Kero

17h00-17h30	Matthew J. Genge (Imperial College London, UK) "The nature and diversity of micrometeorites" (invited)
17h30-17h50	Peter Jenniskens (SETI Inst., USA) "Goals and objectives of the IAU Commission 22's Task Group on Meteor Shower Nomenclature" (round table)
17h50-18h00	Douglas O. ReVelle (Los Alamos National Laboratory, USA) "Public Announcement: Progress in fireball detections"

18h00-19h00	Poster session

Thursday, June 14

Auditorium conference room

Session 5: Astromineralogy: Comet 81P/Wild 2 and cometary meteoroids

Morning session

Session chairs: R. Hawkes and J. Llorca

9h30-10h00	George J. Flynn (SUNY-Plattsburgh, USA) "Elemental Composition of Dust Collected at Comet 81P/Wild 2 by NASA's Stardust Spacecraft" (invited)
10h00-10h30	Frans J.M. Rietmeijer (University of New Mexico, USA) "Cometary meteoroids after Stardust" (invited)
10h30-11h00	Alessandra Rotundi (Università degli Studi di Napoli "Parthenope", Italy) et al., "Combined Micro-IR and Micro-Raman Analyses of Comet 81P/Wild 2 Particles Collected by Stardust" (invited)

11h00-11h30	Coffee break

11h30-12h00	Jiri Borovicka et al. (Ondrejov Observatory, Czech Republic) "Properties of cometary dust from meteor observation" (invited)
12h00-12h15	Toshihiro Kasuga (Inst. for Astronomy, Univ. of Hawaii, USA) "Metal abundances of meteoroids in meteor showers: solar heating effect on the meteoroids"
12h15-12h45	Josep M. Trigo-Rodríguez (Institute of Space Sciences IEEC-CSIC, Spain) et al. "Structure and composition of cometary meteoroids: clues from comet 81P/Wild 2, carbonaceous chondrites and IDPs" (invited)

Afternoon:

15h00-19h00: Barcelona tour. Visit to the Sagrada Familia cathedral, Park Güell, and the Modernism route.

20h00: Complementary dinner for all meeting attendants in Restaurant *Magnum 7 Portes*, located in Salvador Espriu 73-75 (nearby Hotel Arts).

Friday, June 15

Àgora conference room

Session 6: Meteoroid flux, Impact Hazard, and Solar System dust

Morning session

Session chairs: J. L. Ortiz and V. Dikarev

9h30-10h00	Clark R. Chapman (Southwest Research Institute, USA) "Meteoroids, meteors, and the NEO Impact Hazard" (invited)
10h00-10h15	Rob Suggs et al. (NASA Marshall Space Flight Center/EV13, USA) "NASA's Lunar Meteoroid Impact Monitoring Program"
10h15-10h30	Valeri Dikarev et al. (Max Planck Inst. For Solar System Res., Germany) "Understanding the WMAP Results: The Low-l Anomalies and Dust in the Vicinity of the Solar System"
10h30-10h45	Munetaka Ueno et al. (Univ. of Tokio, Japan) "Observations of Zodiacal Light during the cruising phase of PLANET-C/VCO Mission"
10h45-11h00	G. Drolshagen et al. (ESA/ESTEC, The Netherlands) "Comparison of meteoroid flux models for near Earth space"

11h00-11h30	Coffee break

11h30-12h00	Closure talk: Joseph A. Nuth (NASA Goddard Space Flight Center, USA) "What was the chemical composition of the planetesimals that formed the terrestrial planets?" (invited)

12h00-12h30	Conference summary and closure ceremony

METEOROIDS 2007
INDEX OF CONTRIBUTIONS

Session: 1:
OBSERVATIONAL TECHNIQUES AND METEOR DETECTION PROGRAMS

SESSION 1: INVITED TALKS
(by alphabetical order)

Janches, Diego - NorthWest Research Associates/CoRA Division
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Title: Meteor Head-Echo Observations Using High Power and Large Aperture Radar: A Review of Recent Results

Abstract: Meteor head-echo observations using High Power and Large Aperture (HPLA) radars have been routinely used for micrometeor studies for over a decade. The head-echo is the radar-reflective plasma region traveling with the meteoroid and its detection allows for very precise determination of instantaneous meteor altitude, velocity and deceleration. Unlike SMR, HPLA radars are very different instruments when compared one to another. The operating frequencies range from 50 MHz for the Jicamarca Radio Observatory (JRO) in Peru to 1.29 GHz for the Sondrestrom radar (SR) in Greenland. The antenna configurations are also different. While JRO consists of 18,000 dipoles in a 300m X 300m square array, the Arecibo Observatory (AO) in Puerto Rico is a 300 m in diameter spherical single dish transmitting at 430 MHz and SR and ALTAIR, in the Marshall Islands, consist of ~46 ft diameter single dishes. Thus, it is of crucial importance not to generalize these instruments. In this paper we review the different systems under operation and the methodologies used to determine meteor parameter distributions. We present observed and modeled results and compare with those from SMR studies and show that agreement is found when different instrumental sensitivity effects are considered.

ReVelle, Douglas O. - Los Alamos National Laboratory
Corresponding Email: revelle@lanl.gov

Title: Acoustic-Gravity Waves from Bolide Sources

Abstract: We have coupled together near- and far-field acoustic-gravity wave (AGW) theories with large bolide entry models to predict either weak shock AGW signals at close range or linearized AGW signals at great ranges (or both possibilities) from such events. We have used the large bolide, source entry modeling techniques of ReVelle (2005, 2007) to establish the appropriate initial "explosion" conditions for various source types. To distinguish transitions from near-field, blast wave, high frequency, weak shock signals from the atmospheric response as a low frequency, discrete, multi-modal composite Lamb wave (a weakly dispersed pulse), we have used the viscous Lamb wave theory of A.D. Pierce (1963) for a hydrostatic, isothermal and windless, model atmosphere. This allows prediction of the Lamb wave formation/dominance distances as a function of the Lamb wave frequency (proportional to the source energy) and of the source altitude above the ground, etc. Finally, to evaluate these wave source modeling and propagation procedures, we will compare our predictions against 4 large

bolide entries that were detected using AGW, namely, the Great Siberian (Tunguska) bolide, the Revelstoke bolide of March 31, 1965 over Canada, the Crete bolide of June 6, 2002 and the September 3, 2004 Antarctic bolide.

Spurný, Pavel - Astronomical Institute of the Czech Academy of Sciences, 251 65 Ondrejov Observatory, Czech Republic
Bland, Phil A. - Imperial College London, SW7 2AZ, United Kingdom
Borovicka, Jiri - Astronomical Institute of the Czech Academy of Sciences, 251 65 Ondrejov Observatory, Czech Republic
Shrbeny, Lukas - Astronomical Institute of the Czech Academy of Sciences, 251 65 Ondrejov Observatory, Czech Republic
Corresponding Email: spurny@asu.cas.cz

Title: Fireball observations in Central Europe and Western Australia – instruments, methods and results

Abstract: In last several years the Czech part of the European Fireball Network (EN) was completely modernized. Original manually operated fish-eye cameras were gradually replaced with new generation cameras, the modern and sophisticated completely autonomous fireball observatories (AFO), which were recently developed in the Czech Republic. We briefly describe basic design and work of this new instrument and its deployment in the Czech stations of the EN. Along with this new modern instrument we developed also new software for measurement of photographic records which made this time-consuming work more efficient, easier and even more precise. This observing system based on AFO's provides us with very complex and precise data on fireballs we got never before. To demonstrate this fact, we present complete data on atmospheric trajectories, orbits, lightcurves and dynamics on several exceptional EN fireballs recently recorded in scope of our network. Moreover, a new fireball network was recently established in the Nullarbor Region of Australia, a desert that has proved eminently suitable for observation of fireballs and locating meteorites. This network is based on the modified AFO's designed to operate in remote areas of the Australian desert. We present unique data on fireballs firstly recorded from southern hemisphere.

SESSION 1: ORAL CONTRIBUTIONS

(by alphabetical order)

Atreya, Prakash - Armagh Observatory
Christou, Apostolos - Armagh Observatory
Corresponding Email: atr@arm.ac.uk

Title: The Armagh Observatory meteor camera cluster: Overview and status

Abstract: Armagh Observatory installed a sky monitoring system consisting of two wide angle (90°) and one medium angle (52°) cameras in July 2005. The médium angle camera is part of a double station setup with a similar camera operated by amateur astronomer Robert Cobain in Bangor, ~73km ENE of Armagh. All cameras use UFOCapture to record meteors automatically; software for off-line photometry, astrometry and double station calculations is being currently developed. The specifications of the cameras and cluster configurations are described in detail. There were 2425 single station meteors (1167, 806 and 861 by the medium-angle and the wide-angle cameras respectively) and 547 double station meteors recorded during the months July 2005 to Dec 2006. About 212 double station meteors were recorded by more than one camera in the cluster. The effects of weather conditions on camera productivity will be discussed. The distribution of single and double station meteor counts observed for the years 2005 and 2006 and calibrated for weather conditions will be presented. Interesting events such as major showers and fireballs will be highlighted.

Brown, Peter G. - Department of Physics and Astronomy, University of Western Ontario, 1151 Richmond Street, London, Ontario, N6A 3K7, Canada.
Edwards, Wayne N. - Department of Earth Sciences, University of Western Ontario, 1151 Richmond Street, London, Ontario, N6A 5B7, Canada
Weryk, Robert J. - Department of Physics and Astronomy, University of Western Ontario, 1151 Richmond Street, London, Ontario, N6A 3K7, Canada.
Corresponding Email: pbrown@uwo.ca

Title: The Southern Ontario Meteor Network (SOMN) – Overview of Sensors, Analysis Techniques and Status

Abstract: Advances in ablation modeling and associated improvements in the interpretation of flight behaviour of meteoroids has permitted better interpretation of their physical properties and the physics of meteoroid ablation. However, many parameters in ablation models remain poorly constrained, such that a large suite of solutions often satisfies the available data. In most cases, input data for modeling involves optical, multi-station records which may only provide metric data together with photometric and/or dynamic masses. In an attempt to provide more comprehensive constraints for a large number of meteors, coordinated multi-sensor observations have begun as part of the Southern Ontario Meteor Network (SOMN). The SOMN currently consists of a multi-frequency radar (The Canadian Meteor Orbit Radar), the Southern Ontario All-sky video network, the Elginfield Infrasound Array (ELFO) and a seismic station. Additionally, a multi-channel VLF receiver and multi-band high speed

photometers are being constructed to add to the suite of data gathered for individual meteor events. All sensors are spatially and temporally calibrated so that individual meteor events can be examined at high time resolution as a function of radiation production, ionization and shock production. SOMN operations will be discussed and first results presented.

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Olsson, Roland - Ostfold University College, N-1757 Halden, Norway
Hansen, Stig-Erland - Ostfold University College, N-1757 Halden, Norway
Lindblad, Thomas - Royal Institute of Technology, Department of Physics, S-106 91 Stockholm
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Title: Meteorite's signal characterization and classification using Machine Learning Algorithms

Abstract: Bolides entering the Earth's atmosphere generate infrasound signals that can be detected over large distances. Because of increasing number of infrasound station being deployed around the world meteorite entry evidences would probably occur more frequently in the next years. Managing a continuous flow of data, automation of the detection and classification process is important. In this paper we present classification results of meteorite's infrasonic signals using well known machine learning algorithms together with three data pre-processing: (1) Time Scale Spectrum (TSS), (2) Cepstral Coefficients and their Derivatives (CCD), (3) Discrete Wavelets Transform (DWT).

Edwards, Wayne - Department of Earth Sciences, University of Western Ontario, London, Ontario, N6A 5B7, Canada.
Brown, Peter - Department of Physics and Astronomy, University of Western Ontario, London, Ontario, N6A 3K7, Canada.
Weryk, Robert - Department of Physics and Astronomy, University of Western Ontario, London, Ontario, N6A 3K7, Canada.
Corresponding Email: wedwards@uwo.ca

Title: Infrasonic observations of meteoroids: Preliminary results from the coordinated optical-radar-infrasound observing campaign at SOMN.

Abstract: Observations of infrasonic sound from large >1m diameter meteoroids have been well documented in the literature. These observations are becoming more common with the inception of the International Monitoring System's network of globally distributed infrasound stations and the revival of infrasound as a monitoring tool. However, similar infrasonic observations of smaller (<10 cm diameter) meteoroids remain rare: only a handful of these are associated with well constrained sources. As a result, fundamental meteor infrasound theory and its predictions have remained generally untested and unconstrained by observation for more than 30 years. Preliminary results of an ongoing coordinated campaign using the Southern Ontario Meteor Network (SOMN), the Canadian Meteor Orbit Radar (CMOR), and the Elginfield infrasonic array (ELFO) to detect infrasound from these small regional

meteoroids and spatially constrain their source regions and meteoroids will be presented. We find that regional meteor infrasound detection is more common than previously thought, with an average of one meteor detection per month over the course of the 1 year observational window at ELFO. Individual coordinated observations from this campaign will be described, including commonalities in signal characteristics, probable source energies/locations and mechanisms.
Comparisons with predictions from cylindrical blast wave theory will also be discussed.

Kozak, Pavlo - Astronomical Observatory of National Taras Shevchenko University, Kyiv, Ukraine
Corresponding Email: kozak@observ.univ.kiev.ua

Title: "Falling Star" – software for complete processing of double-station TV observations of meteors

Abstract: Software called "Falling Star" has been developing during last ten years in department of small bodies of the Solar system at Astronomical Observatory of Kyiv National Taras Shevchenko University for digital processing of double-station TV observations of meteors. It is designed for measurements and calculation of both kinematical and photometrical parameters of a faint meteor observed with any TV/video system. The software is aimed to realize the processing of meteor observations in the laboratory conditions, where the observational data presented on video-tapes are preliminary digitized and then converted form standard AVI into own TVS (TV sequence) format with additional astronomical information like date, time of observations, geographical position of point of observations and horizontal coordinates of optical axis orientation. These additional parameters give the possibility to calculate the right ascension and declination of optical center and to carry out the identification of reference stars automatically. "Falling Star" includes a range of automated procedures for star-like object measurements in TV frames, star identification with the catalogue, the search of movable meteor-like objects inside frame, calculation of its equatorial coordinates and photometrical measurements. Finally meteor trajectory parameters, orbital elements and brightness curves are calculated. Errors of calculations are determined using Monte-Carlo method.

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Mathews, John D. - Communications and Space Sciences Laboratory, The Pennsylvania State University, University Park, PA 16802-2707, USA
Urbina, Julio - Communications and Space Sciences Laboratory, The Pennsylvania State University, University Park, PA 16802-2707, USA
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Title: A radio science perspective on Range-Spread Trail Echoes observed at Jicamarca

Abstract: Results from June 2006 and March 2007 50 MHz radar campaigns at the Jicamarca Radio Observatory (JRO) reveal that full understanding of Range-Spread Trail Echoes (RSTEs) must involve knowledge of the trail viewing angle relative to kB as a function of location along the meteoroid trajectory. A statistical study RSTEs using

the JRO main array demonstrates that an overwhelming majority of long duration (>15 seconds) trails occur in the kB region of the radar. Short duration (<5 seconds) trails constitute a large majority of the trails and are seen throughout the illuminated volume although with a statistically significant kB preference indicating that trail duration is also a function of factors such as meteoroid mass and energy. Given the apparent aspect sensitivity of the trail as it expands parallel to the geomagnetic field, we note that short duration echoes away from the kB zone might be longer duration echoes if viewed from the correct geometry. We present first results from a multi-static radar observations in which meteor events were viewed at two aspect angles providing further insights into the RSTE phenomenon.

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Meisel, David D. - Computer Science Department, SUNY-Geneseo, Geneseo, NY 14454-1401, USA
Heinselman, Craig J. - SRI International, Menlo Park, CA 94025, USA
Corresponding Email: JDMathews@psu.edu

Title: Radio and meteor science outcomes from comparisons of meteor radar observations at AMISR Poker Flat, Sondrestrom, and Arecibo.

Abstract: Radio science and meteor physics issues regarding meteor "head-echo" observations with high power, large aperture (HPLA) radars include the frequency and latitude dependency of the observed meteor altitude, speed, and deceleration distributions. We address these issues via the first ever use and analysis of meteor observations from the AMISR Poker Flat (449.3 MHz), Sondrestrom (1290 MHz), and Arecibo (430 MHz) radars. The AMISR and Sondrestrom radars are located near the arctic circle while Arecibo is in the tropics. The meteors observed at each radar were detected and analyzed using the same automated FFT periodic micrometeor searching algorithm. Meteor parameters (event altitude, velocity, and deceleration distributions) from all three facilities are compared revealing a striking altitude "ceiling effect" in the 1290 MHz results relative to the 430/449.3 MHz results. This effect is even more striking in that the Arecibo and AMISR distributions are similar even though the two radars are over 1000 times different in sensitivity and at very different latitudes tus providing the first statistical evidence that HPLA meteor radar observations are dominated by the incident wavelength, regardless of the other radar parameters. We also offer insights into the meteoroid "terminal process."

ReVelle, Doug. O. - Los Alamos National Laboratory
Sukara, O. - University of Western Ontario
Brown, Peter - University of Western Ontario
Edwards, Wayne N. - University of Western Ontario
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Title: Reanalysis of the Large Bolide Microbarograph Data

Abstract: During the period from 1960-1974, the U.S. Air Force Technical Application Center recorded at least ten very large bolides at multiple locations worldwide using ground-based microbarograph array, acoustic-gravity wave (AGW) detection techniques. The deduced bolide source energies ranged from 0.1 kt to > 1 Mt (TNT equivalent) and were subsequently converted by ReVelle and Wetherill into a global influx rate. With the exception of one event, all procedures used for evaluating the source energies utilized analog cross-correlation detection and location techniques, etc. In this new work we have digitized the original dataset in the original 3 dB down pass-bands, namely in the LF (low frequency) band from 44-440 s and in the HF (high frequency) band from 25 s -8.2 Hz, to reassess our earlier findings. In addition to reanalysis of the propagation back azimuths and signal velocity comparisons, we have also performed signal amplitude analyses including horizontal wind propagation effects using UKMO (United Kingdom Meteorological Office) operational model results as well as performed FFT analyses of power spectra, etc. on this extensive dataset. An additional goal was a comparison of the resulting influx determinations against more recent results and against the recent propagation analyses of Edwards et al (2006).

Trigo-Rodríguez, Josep M. - Institute of Space Sciences (CSIC-IEEC)
Castro-Tirado, Alberto J. - Instituto de Astrofísica de Andalucía (CSIC)
Gural, Peter - Science Applications International Corp.
Madiedo, José M. - Universidad de Huelva
Llorca, Jordi - Universitat Politècnica de Catalunya
Fabregat, Juan - Universitat de València
Vítek, Standa - Instituto de Astrofísica de Andalucía (CSIC)
Ortiz, José L. - Instituto de Astrofísica de Andalucía (CSIC)
Docobo, José A. - Universidade Santiago de Compostela
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Title: Determination of meteoroid orbits and spatial fluxes by using high-res all-sky CCD cameras

Abstract: Since 2005, continuous meteor and fireball observations have been carried out by the SPanish Meteor Network (SPMN) using all sky CCD cameras located at several stations around Spain. As a result of the continuous monitoring, several bolides have been recorded, as well as information on unexpected high meteor activity such as the 2006 Orionid outburst. Trajectory and orbital data of several remarkable cases are presented as an example of the overall system capabilities. The SPMN measurements also include the counting of recorded meteors associated with each meteor stream, from which meteoroid fluxes are obtained. To help facilitate continuous coverage of meteoric activity, a recent achievement has been the development of software for allowing automatic detection of meteors and fireballs. This crucial capability will allow less labor intensive review of imagery, and supports the expansion of the network to cover all of Spain during the next years. Our main research goals are: (1) Accurate trajectory and orbital study of large bolides to define possible meteorite recovery cases, (2) Determination of meteoroid fluxes and orbital data from cometary and asteroidal sources, (3) Development of CCD meteor spectroscopy to study the chemical composition of meteoroids, and (4) Characterization of minor meteor shower activity.

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Brown, Peter G. - Department of Physics and Astronomy, University of Western Ontario, 1151 Richmond Street, London, Ontario, N6A 3K7, Canada.
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Title: Comparisons of simultaneously detected radar and electro-optical meteors

Abstract:
We present comparisons of meteors detected (down to a limiting magnitude of +6) simultaneously by the Canadian Meteor Orbit Radar (CMOR) and several image-intensified CCD cameras. We employ both absolute time-based and spatial measurement calibrations to provide two independent means of comparing the optical and radar data. The electro-optical astrometry has been used to validate our radar orbit determinations, and to establish true error estimates for individual radar-determined meteoroid orbits. We find that CMOR has an interferometric accuracy of 1.4 ± 0.9 degrees and a typical speed error of 5.5 ± 3.5 percent for our set of analysed meteors. Additionally, application of a pulse fitting routine is demonstrated to produce range accuracies of 0.8 ± 0.6 km given our 3 km sampling interval. These multi-sensor calibrated events will allow for more realistic characterisation of the error bounds of more than two million meteoroid orbits detected by CMOR during its first five years of operation, and will ultimately provide a direct link between the meteor photometric and radar mass scales in our mass range.

SESSION 1: POSTERS
(by alphabetical order)

ℙ1

Arrowsmith, Stephen - Los Alamos National Laboratory
ReVelle, Doug - Los Alamos National Laboratory
Brown, Peter - University of Western Ontario
Edwards, Wayne - University of Western Ontario
Corresponding Email: arrows@lanl.gov

Title: Global detection of Infrasonic signals from large bolides

Abstract: We present the infrasonic recordings of three large bolides that were observed at numerous International Monitoring System (IMS) infrasound arrays. By measuring noise spectra and performing detailed propagation modeling, we investigate the causes of the asymmetric geographic distributions of observations. We quantify the relative importance of path and site-noise effects on the detectability of each event. We also comment on the effect of site-noise on the recorded signal durations. These results have implications for the use of infrasound measurements (in particular those from IMS stations) as a tool for evaluating the global flux of near-Earth objects.

ℙ2

Bettonvil, Felix. C.M. - Astronomical Institute, Utrecht University, The Netherlands
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Title: Velocity determination of meteors based on sinodial modulation and frequency analysis.

Abstract: In meteor photography the velocity of meteors is generally obtained from a chopper which blocks periodically the incident light beam in front of the camera lens. We suggest to modulate the meteor trail instead with a triangular- or sinodial function. The advantage is that all pixels contribute in the velocity measurement and Fourier analysis and/or wavelet analysis techniques can reveal the dominant frequency in the trail -representing the shutter speed- more precisely. Slow variations in brightness, caused by brightness variations in the meteor trail, flares or persistent trails give negligible interference due to their different frequency regime. We did simulations to study the method in more detail. For a meteor imaged with a medium resolution (6'/pxl) All-sky camera we could find the modulation frequency again with an inaccuracy of 0.4% and estimated from the analysis that the uncertainty was 0.5%. Experimental observations showed similar results. The simulations showed that highest precision is obtained for fast modulation frequencies. Although intended for All-sky imaging the method works fine too for longer focal lengths cameras which could lead to uncertainties below 0.1%. Especially then stable and accurate motor systems are crucial.

ℙ3

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Eaton, David - Department of Earth Sciences, University of Western Ontario, London, Ontario, N6A 5B7, Canada.
McCausland, Philip - Department of Earth Sciences, University of Western Ontario, London, Ontario, N6A 5B7, Canada.
ReVelle, Douglas - Atmospheric, Climate and Environmental Dynamics, Meteorological Modeling Team, P.O. Box 1663, MS D401, Los Alamos National Laboratory, Los Alamos, New Mexico 87545 USA.
Brown, Peter - Department of Physics and Astronomy, University of Western Ontario, London, Ontario, N6A 3K7, Canada.
Corresponding Email: wedwards@uwo.ca

Title: Observations of infrasonic-seismic coupling for an artificial meteor-analog: STARDUST sample return capsule re-entry.

Abstract: Atmospheric shock waves and airbursts of meteoroids are commonly detected by seismograph networks, yet a lack of calibration limits quantitative analysis of these signals. Previous estimates of air-to-ground energy coupling efficiency have ranged between 10-4 and 10-7. We report here co-located seismic and infrasonic measurements of the hypervelocity re-entry of NASA's Stardust Sample Return Capsule (January 15, 2006). Our observations of the far-field shockwave yield a coupling efficiency of 2.13 ± 0.15%, 2-5 orders of magnitude greater than some previous estimates. After passage of the ballistic shock wave, seismic measurements reveal a strong narrow-band coda, whereas infrasonic measurements contain an enigmatic series of pulses ~10 s after the initial pulse, synchronous with termination of the seismic coda. Laboratory and in-situ measurements of soil properties, time-frequency analysis and numerical simulations show this seismic coda is an air-coupled Rayleigh wave, and the late-arriving infrasonic pulses are energetic components (Airy phases) of this wave. Our results confirm that seismic observations can yield realistic estimates of kinetic energy of meteoroids, provided that the seismic properties of the near-surface are well known. We also show that the air-coupled Rayleigh wave produces seismic-acoustic wave interaction that can lead to ground-air coupling analogous to earthquake-induced sounds.

ℙ4

Filin, I.V. - Kazan State University
Lubimov, D.V. - Kazan State University
Bojko, B.P. - Kazan State University
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Title: Development of technology of measurement of radiant coordinates and speeds of meteoric streams and microstreams by goniometric data of one-position radar.

Abstract: Opportunities of one-position radar engineering of measurement of radiant coordinates and speeds of meteoric streams have been essentially extended with development of discrete quasytomographic analysis of goniometric data on microstream hypothesis. Purpose of given work was to investigate opportunity to reduce mistakes of speed discretization and errors of difraction method in conditions when distribution of

speeds incide microstream is not known and meteor numbers are limited. Imitating model shows the estimation of speed in middle of selected interval at low threshold number of registered meteors in microstream is equivalent to estimation on mode of distribution and close to estimation of average value on set of number of all meteors included in this distribution not just on set of registered meteors in this interval. It is shown that question of possible displacement of grid borders of discretization on maximum for angular and speed distribution is as for displacement of grid on half of discretization interval. It is shown that such action in some conditions allow to improve angular estimation up to 1dgr. It is shown that correction of zenithal attraction can be taken into account in algorithm of construction of lines of possible radiant position which differ from big circle lines.

ℙ5

Gural, Peter S. - SAIC
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Title: Algorithms and Software for Meteor Detection and Flux Modeling

Abstract: An ever increasing variety of electronic instrumentation is being brought to bear in meteor studies and analysis. These can run the gamut from all-sky imagers and wide-field video, down to narrow field-of-view telescopic and spectroscopic observations. Each presents unique detection difficulties when attempting automated processing of the imagery, specifically in terms of matching algorithmic choice to imagery characteristics and data rate. Presented herein is a review of the algorithms implemented in software over the past few years to detect meteor tracks in the Spanish Fireball Network all-sky images, intensified video recordings of meteor showers and storms since 1998, a detection/cueing technology for rapid slew and tracking of meteors, telescopic observations of meteors, and Lunar meteoroid impact flash detection. In addition, many of the imaging systems used in meteor studies, need to be calibrated to correct their flux measurements for biases induced from meteoroid stream encounter parameters, imaging system characteristics, atmospheric effects, and viewing geometry to obtain spatial number densities. These corrections are now possible with a high-fidelity meteor-simulation tool that has the additional capability to convert spatial flux measurements to human observer zenith hourly rates.

ℙ6

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Slipchenko Mykola I. - Kharkiv National University of Radioelectronics, Lenin ave., 14, Kharkiv, 61166, Ukraine
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Title: The International Heliophysical Year 2007 and historical significance of the meteor program of the International Geophysical Year 1957

Abstract: In this paper the spectrum of problems, which could be solved within the framework of the global international program of coordinated meteor researches during the International Heliophysical Year 2007-2009 are presented. Some open questions are

e.g. the estimations of the influx of meteor substance into the Earth's atmosphere and the impact hazard near the Earth's orbit. These topics are considered on the basis of the significant potential of the accumulated fund of knowledge as a result of wide introduction of meteor methods of researches of near Earth space during time the IGY 1957 and after. Meteors in many aspects have appeared extremely important for IGY 1957 with coming of a space age and revolutionary introduction into scientific researches of radar-tracking methods. In 1955 after the approval of the program on research of meteors in the USSR the name of section V the Ionosphere of the IGY was officially used in Russian language as "The Ionosphere and Meteors". The IGY had given impetus to the development of meteor astronomy all over the world and first of all in the republics of the USSR in Russian language. The data about powerful scientific heritage, and also the map of the past significant events are presented.

ℙ7

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Lohwiessen, F. - Werkgroep Meteoren
Mc Auliffe, Jonathan - ESA/ESTEC
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Title: A permanent double-station setup for meteor video observations in the Netherlands - first results

Abstract: The meteor group of ESA/ESTEC has been performing ground-based observations of meteors with image-intensified video cameras since 1998. The main focus of the work was to perform double-station observations during meteor streams, e.g. for the Leonid storms in 1999 and 2001/2002. Since the end of 2006, some of the video cameras are used in a permanent double-station setup, which monitors the night sky every clear night. This poster will describe the setup, give a summary of the data collected, and present first results derived from the observations.

ℙ8

Koten, Pavel - Astronomical Institute of the Academy of Sciences, Ondrejov, Czech Republic
Spurný, Pavel - Astronomical Institute of the Academy of Sciences, Ondrejov, Czech Republic
Abe, Shinsuke - Graduate School of Sciences and Technology, Kobe University, Japan
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Title: Remote control CCD camera for meteor observations

Abstract: New camera system have been developed using the commercial off-the-shelf components. It is based on the Watec CCD camera, which is mounted on the steerable mounting. The mounting is connected to the video server. Web-based interface enables to remotely aim the camera to desired azimuth and elevation. The video signal is processed in real-time by a computer. Because the system operates within the reach of the photographic network, it is expected that it will provide simultaneous data for some

fireballs. Due to better sensitivity and instant imaging mode of the used CCD camera we will be able to describe in more detail fragmentation processes of larger meteoroids as well as the beginning and terminal parts of the luminous trajectories of some meteors. We introduce this system as well as present first cases of fireballs, which were detected also by this camera.

ℙ9

Noguchi, Kazuya - Kochi University of Technology
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Title: Development of auto meteor echo counting software on HROFFT spectrograms

Abstract: Ham-band radio meteor observation (HRO) has been operated by amateur meteor observers because it can easily be realized at home only with a simple Ham antenna, a special receiver of ITEC "HRO-Rx1a," and a PC. Meteor echo signals are down-converted to audio signals by receivers and can be input to a PC through a onboard sound card as a cheap A/D converter. Inputting the signals, quasi real-time FFT analysis is operated by the dedicated software of "HROFFT." Created spectrogram per 10 minutes can be sent to a web site on demand by another FTP software "DT-FTP." This automatic radio observation technique has been tuned and spread worldwide recently, however, HRO observers still have to count each meteor echo on the HROFFT spectrograms by themselves to obtain daily HR (Hourly Rate) curve at each site. One of the recent topics of HRO is post-processing of HROFFT spectrograms. We developed new software of auto-counting of meteor echoes on HROFFT spectrograms by image processing method. The software named "Meteor Echo Counter version 1.0" can make it possible on each HROFFT spectrogram that contains the following functions of: echo counting: long-echo detection, line noise canceling, plane echo canceling, datasheet production, and HR curve plot.

ℙ10

Peña, Antonio - Observatorio Astronómico, Universidad de Valencia, Spain
Fabregat, Juan - Observatorio Astronómico, Universidad de Valencia, Spain
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Title: A robust bolid and fireball detection algorithm for all-sky sequential images

Abstract: The presented algorithm works over sequential images taken at the same night by a fixed all-sky camera. Its major benefits are, on the one hand the ability to remove clouds, and on the other, the low false positive rate achieved. The core of the algorithm is based on the widely used Hough Transform, which is a powerful line detector, as it is capable to detect even broken or incomplete lines, as well as disfigured ones. However, the most important piece of this algorithm is the preprocessing, which cleans the image to isolate as much as possible the potential bolids or fireballs. This includes gray-scale filtering, image registration, binarization and morphological transformation. Also a postprocessing is done to remove false positives related to linear cloud formations, as they are repeated over successive chronologicaly ordered images. Nowadays we are able to detect up to the 33% of the bolids or fireballs captured in one night (now

increasing this rate by fine-tuning some parameters), with a minimum false positive rate related to airplane traces. At the moment this algorithm is developed as a prototype in Matlab, and it is planned to move to C for real scientific work.

ℙ11

Svoren, Ján - Astronomical Institute of the Slovak Academy of Sciences
Spurný, Pavel - Astronomical Institute of the Academy of Sciences of the Czech Republic
Porubkan, Vladimír - Astronomical Institute of the Slovak Academy of Sciences
Kachuchová, Zuzana - Astronomical Institute of the Slovak Academy of Sciences
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Title: A new bolide station at the High Tatra Mountains

Abstract: The European Fireball Network (EN) is operating since 1963 and one of its stable stations, from the very beginning, is the station at the Skalnaté Pleso Observatory in the High Tatras. The station is sited at a hight of 1788 m. More than 2900 expositions has been made at the Skalnaté Pleso station since 1964 and among them one significant and spectacular event was recorded - bolide Turji-Remety in 2001 (fall of about 450 kg meteorite, Spurný and Porubčan 2002). The systematic looking for the meteorite was unsuccessful. A disadvantage of the Skalnate Pleso position is a close mountain range shielding western horizon up to an elevation of 22 degrees. Therefore, it was decided to move the station to a near only 1 km distant Lomnicky Peak (2636 m above the sea level), the site of the coronal station of the Astronomical Institute of the Slovak Academy of Sciences. The new station having an ideal horizon has been operating since July 2007. This station is equipped with the Autonomous Fireball Observatory of the Astronomical Institute of the Czech Academy of Sciences, which are already used in the Czech part of the EN for several years.

ℙ12

Toth, Juraj - Department of Astronomy, Physics of the Earth and Meteorology, Faculty of Mathematics, Physics and Informatics, Comenius University Bratislava, Slovak Republic
Kornos, Leonard - Department of Astronomy, Physics of the Earth and Meteorology, Faculty of Mathematics, Physics and Informatics, Comenius University Bratislava, Slovak Republic
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Title: TV meteor observations from Modra

Abstract: We present results of our double station test observations of Ursids 2004 and Geminids 2006. We discuss the astrometric precision of the UFOAnalyser software, we used for our analyses. The fixed fish-eye TV system was developed for meteor activity monitoring, in Modra (Astronomical and Geophysical Observatory, Comenius University). We present experience as well as results from this new TV system. The second station is planned to be installed in the near future 80km far from Modra.

ℙ13

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Welch, D. L. - Department of Physics and Astronomy, McMaster University, 1280 Main Street West, Hamilton, Ontario, L8S 4M1, Canada.
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Title: The Southern Ontario all-sky meteor camera network

Abstract: We have developed an automated network of all-sky CCD video systems (making meteoroids ablating over Southern Ontario, Canada. The system currently consists of five fully autonomous stations (the largest baseline is 180 km), each running a video rate recorder with sufficient resolution to determine meteoroid trajectories with a typical precision of ~300 m (at best) to ~1 km (at worst). The sensitivity of the camera is close to a magnitude of +1 which allows for astrometric calibrations using field stars. Photometric procedures have also been developed, tested, and calibrated against measurements made using other sensors of the Southern Ontario Meteor Network, and have shown a limiting magnitude for meteors of about -2 with the current detection algorithm. The system design and operation will be discussed, and some initial results from the first three years of operations will be presented.

ℙ14

Yasunori, Fujiwara - Nippon Meteor Society
Yoshiyuki, Hamaguchi - Nippon Meteor Society
Takuji, Nakamura - RISH, Kyoto University
Masaki, Tsutsumi - National Institute of Polar Research, Japan

Makoto, Abo - Tokyo Metropolitan University
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Title: Meteor orbit determinations with a MU radar

Abstract: The MU radar of Kyoto University, which is a MST radar with a frequency and a peak power of 46.5 MHz and 1 MW, respectively, has been successfullyapplied to meteor studies by using its very high versatility. The MU radar was recently renews. In addition to the signal processing unit up-graded from a 4 analog receiver system to a 25 digital receiver system (25 channels), GPS synchronized radar operation and the addition of two outlying receiving stations allow the determination of the trajectories and speeds of meteoroids. We will present the system overview and some preliminary results.

Session 2:
METEOR SHOWERS' ACTIVITY AND FORECASTING

SESSION 2: INVITED TALKS
(by alphabetical order)

Brown, Peter G. - Department of Physics and Astronomy, University of Western Ontario, London, Ontario, N6A 3K7, Canada.
Weryk, Robert J. - Department of Physics and Astronomy, University of Western Ontario, London, Ontario, N6A 3K7, Canada
Wong, Daniel K. - Department of Physics and Astronomy, University of Western Ontario, London, Ontario, N6A 3K7, Canada
Jones, James - Department of Physics and Astronomy, University of Western Ontario, London, Ontario, N6A 3K7, Canada
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Title: The Canadian Meteor Orbit Radar (CMOR) Meteor Shower Catalogue

Abstract: The Canadian Meteor Orbit Radar is a multi-frequency backscatter radar which has been in routine operation since 1999, with an orbit measurement capability since 2002. In total, CMOR has measured over 2 million orbits of meteoroids with masses greater than 10 micograms, while recording more than 10 million meteor echoes in total. We have applied a two stage comparative technique for identifying meteor showers by making use of clustering in radiants and velocities without employing orbital element comparisons directly. From the large dataset of single station echoes, combined radiant activity maps have been constructed by binning and then stacking each years data per degree of solar longitude. Using the single-station mapping technique described in Jones and Jones (2006) we have identified probable showers from these single station observations. Additionally, using individual radiant and velocity data from the orbital determination routines, we have utilized a wavelet search algorithm in radiant and velocity space to construct a list of probable showers. These two lists were then compared and only showers detected by both techniques, on multiple frequencies and in multiple years were assigned shower status. From this analysis we have identified 44 annual minor and major showers with high reliability.

Sansaturio, María Eugenia - University of Valladolid - NEODyS
Arratia, Oscar - University of Valladolid - NEODyS
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Title: Apophis: The story behind the scenes

Abstract: On Dec 20, 2004 the Minor Planet Center issued the MPEC 2004-Y25 announcing the discovery of a new NEA with designation 2004 MN4. Only two days later, when the Christmas holidays were about to begin, it was already apparent that this asteroid, currently known as Apophis, would be notorious: our close-approach monitoring system, CLOMON2, was already showing a Virtual Impactor (VI) in 2029 reaching the level 2 in the Torino Scale... the first asteroid to reach that level since our monitoring system had been opperational. However, this was just the beginning of what

it was to come in the subsequent days. In this lecture we will give an overview of the NEODyS-CLOMON2 system and provide the details on how Apophis' collision scenario evolved, the way NEODyS' team handled it and the crazy Christmas holidays we had due to this unexpected guest.

Vaubaillon, Jeremie - CALTECH
Reach, William - CALTECH
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Title: Infrared observation of meteoroid streams in the vicinity of cometary nuclei

Abstract: The Spitzer space telescope has recently revealed the structure of meteoroid streams in the vicinity of cometary nuclei. We will show our latest results of a survey and a study of the broken comet 73P/Schwassmann-Wachmann 3. We show that the size distribution index flatened for a size of 100 microns, as already suspected from in situ data (Giotto and Stardust). The following of this work will reveal perturbed trail, far from the cometary nucleus and help to understand the dynamic of meteoroid streams in the Solar System. Finally we will present the circumstances of the Aurigids meteor shower expected on the 1st of September 2007.

Watanabe, Junichi - National Astronomical Observatory of Japan
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Title: Activities of parent comets and related meteor showers

Abstract: Recent applications of the so-called dust trail theory provide us not only a new method to expect the shower activities in the future, but also to explore the past history of cometary activities of relatively dormant objects. As shown in the recent result from the historical display of 1956 of the Phoenicids indicating that the parent object, 2003 WY25, was active enough to supply meteoroids, episodically or continuously, from late 18th through early 18th century, while it seems to be dormant in recent years (Jewitt 2006). The possibilities of such a new approach to clarify the activity history of parent objects by inspecting both the geometrical situation of the dust trails and the meteor shower activities will be reviewed.

SESSION 2: ORAL CONTRIBUTIONS

(by alphabetical order)

Asher, David J. - Armagh Observatory
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Title: Meteor outburst profiles and cometary ejection models

Abstract: The spatial structure of meteor streams, and the activity profiles of their corresponding meteor showers, depend firstly on the distribution of meteoroid orbits soon after ejection from the parent comet nucleus, and secondly on the subsequent dynamical evolution. The latter increases in importance as more time elapses. For younger structures within streams, notably the dust trails that cause sharp meteor outbursts, it is the cometary ejection model (meteoroid production rate as a function of time through the several months of the comet's perihelion return, and velocity distribution of the meteoroids released) that primarily determines the shape and width of the trail structure. This work shows how observed parameters of storms and outbursts can be used to constrain quantitatively the process of meteoroid ejection from the nucleus.

Christou, Apostolos A. - Armagh Observatory, UK
Vaubaillon, Jeremie - Spitzer Science Center, CalTech, USA
Withers, Paul - Center for Space Physics, Boston University, USA
Corresponding Email: aac@star.arm.ac.uk

Title: Annual and outburst meteor activity in the atmospheres and Venus and Mars

Abstract: Several recent works have shown that, just as at the Earth, the near planets Venus and Mars should intersect meteoroid streams associated with both short and long period comets. To date, however, these have been based on two-body orbital proximity criteria alone. We have taken this one step further and simulated numerically the dynamical evolution of trails of meteoroids ejected from several Jupiter-family and Halley-type comets that are potential parents of Venusian and Martian annual showers or episodic outbursts. Our investigation included the triple planet approachers 1P/Halley and 45P/Honda-Mrkos-Padjusakova. We find that both annual showers and occasional outbursts, some being exceptionally intense by Earth standards, can occur at those planets. These do not always correspond to the times calculated by considering the relative orbital geometry. In one case we show the observational signature of an event that took place at Mars in 2003 and was detected by Mars Global Surveyor. Finally, we make predictions for exceptional events that should be similarly observable by spaceborne detectors in the near future.

Gural, Peter S. - SAIC
Jenniskens, Peter - SETI Institute
Corresponding Email: peter.s.gural@saic.com

Title: Spatial Flux Density Characterization during the 1999 Leonid Storm

Abstract:
A detailed spatial flux analysis of the peak of the November 18, 1999 Leonid storm is presented using six simultaneously collected intensified video systems. Each camera system was positioned onboard an aircraft and was pointed to a different portion of the sky, thereby providing enhanced meteor counts over ground observations and greatly improved flux counting
statistics. Analysis of the video tapes provides a refined estimation of the mass ratio and spatial flux density within one hour around the storm's peak. Furthermore, projection of the individual trails into three-dimensional space, given from the many camera views available, shows the non-homogeneity of the stream on the scale of thousands of kilometers. Implications for the pre-entry break-up of larger meteoroids before ablation in Earth's atmosphere will be given.

Jenniskens, Peter – SETI Institute
Vaubaillon, Jeremie - Spitzer Science Center, CalTech, USA
Lyytinen, Esko - Finland
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Title: The upcoming encounter with dust of a long-period comet: the 2007 Aurigid outburst

Abstract:
In the rest of our lives, there will be only one encounter with the dust trail of a known long-period
comet. That encounter occurs on September 1, 2007. It wil cause an outburst of Aurigids around 11:37 UT, in the early morning over California. The meteoroids were ejected in about 82 BC and have circled the Sun once. The meteor shower will be mostly -3 to +2 magnitude meteors, not hampered too much by the bad Moon at that time. We will outline the importance of this astronomical event, what may be learned about this and other long-period comets that are an impact hazard to Earth, and what help can be provided for participation in the observing campaign.

Koten, Pavel - Astronomical Institute of the Academy of Sciences, Ondrejov, Czech Republic
Borovicka, Jiri - Astronomical Institute of the Academy of Sciences, Ondrejov, Czech Republic
Spurný, Pavel - Astronomical Institute of the Academy of Sciences, Ondrejov, Czech Republic
Evans, Stephen - British Astronomical Association, London, United Kingdom
Stork, Rostislav - Astronomical Institute of the Academy of Sciences, Ondrejov, Czech Republic
Elliott, Andrew - British Astronomical Association, London, United Kingdom
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Title: Video observations of the 2006 Leonid outburst

Abstract: We carried out the double station observations of the Leonid meteor shower outburst, which occurred in the morning hours of November 19, 2006. Using the image-intensifier cameras we recorded approximately 100 Leonid meteors. As was predicted the outburst was rich especially in faint meteors. The activity profile shows that the peak of the outburst occurred between 4:30 and 4:45 UT. We use both single and double station recorded meteors to investigate the properties of the Leonid meteoroids

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Nolan, Michael C. - Arecibo Observatory
Harmon, John - Arecibo Observatory
Howell, Ellen - Arecibo Observatory
Campbell, Don - Cornell University
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Title: Large Grains Ejected from 73P/Swassmann-Wachmann 3

Abstract: Arecibo radar observations of fragments B and C of comet 73P showed large (> several-cm) grains in the coma. The first-ever radar delay-Doppler "image" of a cometary coma showed that these grains have lifetimes of at least 1 day. This lifetime suggests that these grains are strong enough to survive the ejection process. Preliminary results suggest that the grain lifetimes are a few days, suggesting that they are largely chunks of ice, in contrast to the longer lived (though probably smaller) grains observed optically.

Rendtel, Jurgen - International Meteor Organization, PF 600118, 14401 Potsdam, Germany
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Title: The Orionid meteor shower observed over 60 years

Abstract:
The evolution of the Orionid activity observed over 60 years is derived from visual data transferred into the VMDB standard format. Both the profiles of the population index r and the rate (ZHR) show recurring features at certain positions while occasional peaks of short duration (few hours FWHM) were not found. The 2006 return showed a significantly enhanced rate by a factor of two lasting for three days combined with a very low value of r. The parameters of the 2006 return are similar to passages of the Earth through meteoroid stream regions of the Leonids 1998 and June-Bootids 1998 which were connected with particles trapped close to commensurabilities.

Ryabova, Galina - Tomsk State University
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Title: Model radiants of the Geminid meteor shower

Abstract:
The Geminid meteoroid stream formation and evolution were studied by the method of nested polynomials and discussed earlier (Ryabova G.O. Proc. Meteoroids 2001 Conf.

(ESA SP-495), 2001, 77-82; Ryabova G.O. MNRAS, 2007, in print). The stream has two layers formed due to differences in orbital parameters of particles ejected from the cometary nucleus before and after
perihelion. The shape of the model activity profiles and configuration of orbital parameters depends on the place where the Earth passes the stream. It is possible that observed radiant structure could serve for calibration of the model, because it was shown that the model radiant structure has a very specific pattern. Model activity area has not a "classical" prolate linear shape, but the configuration of activity centres looks rather like letter "V". During one night of model observations two (or more) activity centres could be observed. A map for velocities distribution in radiant area is also presented.

Sato, Mikiya - National Astronomical Observatory of Japan
Watanabe, Junichi - National Astronomical Observatory of Japan
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Title: Origin of the Orionids 2006 outburst

Abstract:
The outburst of the Orionids was observed in 2006, this strong activity continued about four days. We confirmed that this activity was caused by the dust trails which were formed by meteoroids ejected from 1P/Halley in -1265, -1197 and -910. The meteoroids in these trails had the sextuple orbital period of Jovian one, the orbit of meteoroids extended into the Earth orbit faster than usual due to the mean motion resonance of Jupiter.

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Mitchell, Nicholas J. - CSAOS, University of Bath, Bath BA2 7AY, UK
Latteck, Ralph - Leibniz-Institute of Atmospheric Physics, 18225 Kuehlungsborn, Germany
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Title: Influence of background dust on radar backscatter from meteor trails

Abstract: Meteoroids burn up between about 120 km and 70 km and form ionized trails which can be located by VHF radars. The decay times of radar echoes from underdense meteor trails are mainly determined by ambipolar diffusion. Model studies about the influence of mostly neutral or positively charged background dust on the ambipolar diffusion indicate that trails of weak meteors are mostly influenced. Significant smaller decay times should be observed for weak meteors (low electron line densitiy) than for strong meteors. The variation of meteor decay times in dependence on echo strength, height, and season was studied with continuous radar observations at Arctic/Antarctic latitudes (69°N, 67°S) and at a low latitude site (22°S). Significantly reduced decay times are found for weak echoes above 85 km at 22°S throughout the year and at high

Arctic/Antarctic latitudes in late autumn, winter, and early spring as proposed by the model. In summer at polar latitudes reduced decay times are observed during the appearance of noctilucent clouds and polar mesosphere summer echoes but below 90 km. The observations are discussed in relation to the appearance of icy particles in the summer mesosphere. A possible bias of temperatures estimated from decay times is evaluated.

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Venkata Phani Kumar, D. - Department of Astronomy, Osmania University, Hyderabad, INDIA
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Title: Perseid Meteor Shower Observations by using Indian MST Radar

Abstract: Observational data, obtained during Perseid meteor shower period by using Indian MST radar at Gadanki (13.46º N, 79.18º E; dip 12.5º N), is used to determine the number density of meteoroids through the cross section of the meteor stream. Cross sections are calculated for a number of classes of echo duration (particle size). They are also used to determine the relative flux of the shower in particle size ranges producing radar meteor echoes having durations <0.4s, 0.4-1s and >1 s. Mean activity profiles along the Earth's passage through the stream show a systematic change of the peak activity and the width of the stream depending on the distribution of echo durations across the stream. The pattern of mass distribution index *s*; are presented and discussed. From the observations of Perseid meteor shower of 2004, it is found that the shower is active with a maximum hourly rate of 250 around $?_o$ =140.565 ± 0.16 (12/13 August). The height distribution shows that the activity of the shower is found to be more between 85 km and 115 Km with a peak occurring at about 103 Km. The SNR distribution of the echoes observed during the shower period indicates that the smaller size meteoroids are more compared to larger size meteoroids in the Perseid meteor stream.

SESSION 2: POSTERS
(by alphabetical order)

ℙ15

Ahn, Sang-Hyeon - Korea Astronomy and Space Science Institute
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Title: Historical Meteor outbursts of the past two millennia

Abstract: The historical meteor outbursts are collected from world-wide historical records including those of the east Asian civilization, the European civilization, and the Arabian civilization. We note that the records of east Asian ountries are revisited on the base of source criticism. In particular, we present the Korean records that have been relatively unkown to the academic society. After analysing those data, we find that several prominent meteor outbursts have been observed. One is the Leonid outburst whose arent-comet is the comet Tempel-Tuttle, and the other two are the Orionid and the eta-Aquarid outbursts whose parent-comet is the comet Halley. We obtained the nodal regression rates of these outbursts by applying the least sqaure fits for
their appreance dates. The Orionid and the eta-Aquarid outbursts show the same nodal regression rate within the fitting error. We conclude that the long-lasting meteor outbursts of the past two millennia have been the Leonid, the Lyrid, the Perseid, the eta-Aquarid, and the Orionid outbursts.

ℙ16

Gajdoš, Štefan - Department of Astronomy, Physics of the Earth and Meteorology, Faculty of Mathematics, Physics and Informatics, Comenius University
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Title: Searching for past signs of October Ursa Majorids

Abstract: A new meteor stream - October Ursa Majorids - was detected by Japan observers on Oct.14-16, 2006 (Uehara et al., 2006). Its weak manifestation is clearly identified among coincidental major meteor showers (N,S Taurids, Orionids), as its meteors radiated from higher placed radiant on the northern sky. We tried to find out previous displays of the stream throughout available meteor orbit databases, as well as among ancient celestial phenomena records. With respect to mean orbit of the stream, we suggest the parent body being a comet from Oort cloud.

ℙ17

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Yellaiah, G. - Department of Astronomy, Osmania University, Hyderabad – 500 007, INDIA.

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Title: The studies of Geminid meteor shower activity from 2003 – 2005

Abstract: Observational data on particle size distribution of the Geminid meteor shower is very scanty, particularly at low latitudes. In this paper the observational data from Gadanki radar have been used to determine particles size distribution and the number density of meteoroids inside the stream of the Geminid meteor shower. The meteor echo from the back scattered radar decays exponentially. The decay time (t), is used to classify the meteor echoes of various durations and to calculate the mass of different meteoroids. The mean variation of meteor number density across the stream has been determined for three echo duration classes,
<0.4s, 0.4 – 1s and T > 1 s. We are more interested in the appearance of echoes of various durations, thereby meteors of various masses in order to understand more on filamentary structure of the stream. It is observed that the faint particle flux peaks earlier than the larger particles. The activity of the shower varies negligibly from year to year and this is generally taken to imply that the stream is old. Our results are best comparable with the "scissors" structure model of the meteoroid stream formation of Ryabova (2007) by considering the asteroid 3200 Phaethon as an extinct comet.

ℙ18

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Watanabe, Junichi - National Astronomical Observatory of Japan, Japan
Sato, Mikiya - National Astronomical Observatory of Japan, Japan
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Title: Meteors brought from 73P/Schwassmann-Wachmann 3

Abstract: The nucleus of Comet 73P/Schwassmann-Wachmann had been split into many fragments at least past two returns. Becuse the related dense dust trail has been detected in the space infrared observation, the meteor shower is highly expected in the future. We applied the so-called dust-trail theory to this interesting object, and obtained several results on the future encounter of the dust trail. In this paper we introduce our results on the forecasts.

ℙ19

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Sidorova, A.D. - Kazan State University
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Title: The catalogue of partial orbital structure of the greatest meteoric streams by one-position radar observation.

Abstract: Present work is devoted to the comparative analysis of orbital elements of partial meteoric branches for biggest annual meteoric streams: Day-time Arietids and Geminids according to the monitoring undertaken in Kazan during 1986-2002 with usage of one-position radar. Orbital elements are determined and catalogue of the largest partial branches making these streams is made. Comparison of orbital elements

of two meteoric streams shows that these two streams have much in common. Time of the beginning and maximum of activity of both streams differ for half-year; aphelion distances of partial branches for both streams are close to the Asteroids' Belt; changes of orbital inclinations are close. There is a full semi-annual symmetry of system of partial branches of the streams. Orbits with identical inclinations are symmetric to the ecliptic plane. Longitudes of perihelion and longitudes of ascending nodes differ on 180º. The structure of orbits of both meteoric streams in perihelion area represents something similar to the twisted tape. But only Geminids find out intensive additional branches with time of actions and key parameters similar to parameters of Geminids activity with aphelion distances 18 AU (1986), 15 AU (1987) and 6 AU(1988). Probably, these branches explain the distinction in physical properties of Geminids found out earlier.

P20

Moser, Danielle E. - Meteoroid Environment Office / Morgan, a Stanley Company
Cooke, William J. - Meteoroid Environment Office, Lead / NASA Marshall Space Flight Center
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Title: Updates to the MSFC Meteoroid Stream Model

Abstract:
The Marshall Space Flight Center (MSFC) Meteoroid Stream Model simulates particle ejection and subsequent evolution from comets in order to provide meteor shower forecasts to spacecraft operators for hazard mitigation and planning purposes. The model, previously detailed in Moser & Cooke (2004), has recently been updated; the changes include the implementation of the RADAU integrator, an improved planetary treatment, and the inclusion of general relativistic effects in the force function. The results of these updates are investigated with respect to various meteoroid streams and the outcome presented.

P21

Okamoto, Sadao - The Nippon Meteor Society
Maegawa, Kimio - Fukui National College Of Technology
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Title: Annual and diurnal variation of meteor rates by the forward-scatter radio observation

Abstract: We have observed meteor rates by the forward-scatter simple observing system using the ham beacon (50W CW 53.75MHz) since April 1996. As the result, we detected the activities of the major showers and the annual variation of the activities of the sporadic meteors. We will focus here the results of the annual and diurnal variation of meteor rates in 2006.

P22
Ryabova, Galina - Tomsk State University
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Title: The effect of collisions with sporadic meteoroids on the Geminid stream structure

Abstract: A method for modelling erosive collisions of stream meteoroids with sporadics has been developed. The main purpose was to obtain the influence of collisions on the dispersion and activity profile of the Geminid meteoroid stream. The hypothesis that collisions with sporadics enlarge mass segregation in the stream is also tested.

P23
Shrbeny, Lukas - Astronomical Institute, Ondrejov Observatory
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Title: Exceptional fireball activity of Orionids 2006 from the Czech Fireball Network

Abstract: We report an exceptional fireball activity of Orionid meteor shower in October 2006. In the nights of 20/21 and 21/22 Oct, 2006 the all-sky cameras of Czech part of European Fireball Network (EN) recorded more than thirty Orionid fireballs, more than in the history of decades-long operation of the EN. We present precise atmospheric data, heliocentric orbits of all multi-station fireballs and comparison of light curves of some these fireballs that refer to differences in the inner structure of meteoric bodies originating from Orionid meteor stream with Halley comet as the parent body.

P24
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Title: Observations of Double-station TV meteors in 2004 and 2005

Abstract: We carried out double-station TV observations of every night in 2004 and 2005. As a result, the doubly TV meteor was able to calculate about 1,600 radiant positions and orbital elements. From these data, we report the results obtained on major showers, minor showers and sporadic meteors.

Session: 3:
ORBITS OF METEOROIDS AND DUST

SESSION 3: INVITED TALKS
(by alphabetical order)

Jenniskens, Peter - the SETI institute
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Title: (Mostly) dormant comets in the NEO population that have meteoroid streams.

Abstract: A review is given of where we stand in the study of possible associations between meteoroid streams and (most-of-the-time) asteroid-looking parent bodies, thought to be mostly dormant or extinct comet nuclei. The few established cases, such as the Quadrantids and 2003 EH1, released meteoroids during discrete fragmentation events in the most recent nutation cycle. The evidence for such fragmentation events will be discussed. Most of our meteor showers are suspected to have this type of origin, but many candidate parent bodies (and their associated stream) need further study to establish the link. The orbital distribution of potential parent bodies is evaluated, showing that most candidate parents have not fully decoupled from Jupiter.

Wiegert, Paul - The University of Western Ontario
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Title: The dynamics of low-perihelion meteoroid streams

Abstract:
The Canadian Meteor Orbit Radar (CMOR) has detected a number of weak meteor showers that have not been well-described in the literature. A subsample of these showers 1) are apparently young owing to a relatively small spread in the nodes, 2) do not show a strong orbital resemblance to any known comets or asteroids, 3) are at high inclination 4) are at low perihelion
distances (<< 1 AU) and 5) at small semimajor axes (< 2 AU). Though one might conclude that the absence of a parent object could be the result of its disruption, it is unclear how this relatively inaccesible (dynamically speaking) region of phase space might have been populated by parents in the first place. It will be shown that the Kozai resonance and/or Poynting-Robertson drag can modify meteor stream orbits rapidly (on time scales much less than a precession cycle) and may be responsible for placing some of these streams into their current locations.

Williams, Iwan - Astronomy Unit, Queen Mary, University of London
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Title: Meteorite Streams:-Are they Real?

Abstract: Meteorites represent bodies at the larger end of meteoroids since they are large enough to survive ablation in the Earth's atmosphere. They are thus far less numerous than normal meteoroids that become meteors. A number of meteorites can arrive at near the same time and location and so in some sense represent a stream, but these are just recent fragmentations. Most meteors are 10 million years old. We investigate numerically the survival of streams for this time interval.

SESSION 3: ORAL CONTRIBUTIONS

(by alphabetical order)

Abe, Shinsuke - Kobe University, Japan
Borovicka, Jiri - Ondrejov Observatory, Czech Republic
Meteor Network Teams - Japan
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Title: Orbit and Spectroscopy of Earth-grazing Meteoroid

Abstract: A bright fireball of -8 absolute magnitude appeared at 11:24:07(UT) on 29 March 2006. The fireball detected from 8 stations in Japan, with CCD videos, digital CCD cameras and a cooled-CCD obtained. The meteoroids penetrated into the atmosphere with the initial velocity of 18.85 km/s, reached a minimum height of of 71 km, and then escaped from the Earth's gravity. Atmospheric ablation and fragmentation enabled us to identified the body as type-II, corresponding to carbonaceous chondrite. The detailed of exciting results, orbit and spectroscopy will be presented.

Campbell-Brown, Margaret - University of Western Ontario, London ON Canada
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Title: Directional velocity distribution and flux variation of the sporadic meteoroid sources

Abstract:
The majority of small (millimeter size) meteoroids striking the Earth every year belong to the sporadic sources: the helion/antihelion, apex and toroidal sources. Radar data from the CMOR facility near London, Ontario, Canada provides five years of flux information and velocity distributions at degree resolution, allowing the fine structure of each source to be investigated. We have used five years of orbital data to investigate the time and directional dependence of the velocity distribution of the sporadic meteoroid population, and five years of single-station, statistical directional information to look at flux changes in the sporadic sources on a degree scale. These data can be used to investigate the origin of the sporadic meteoroid sources.

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Title: Remarks on the mean orbits of the meteoroid streams

Abstract: We discus a few points related with the conception of the mean orbit of the meteoroid stream. The most important one, deals with the averaging of the meteoroid's parameters. First we give a short review of the method applied for calculation of the mean orbit of the meteoroid's stream - the methods biased by different defects, e.g. the mean orbital elements do not satisfy the laws of celestial mechanics. Next, we give

practical formulae of a new approach, free from all conceptual faults. Instead of the Keplerian elements, we average the heliocentric vectorial elements, and the solution is obtained by the least squares method completed by two constrains. The corresponding geocentric parameters one may calculate by the theoretical radiant approach. Due to simultaneous averaging of 7 variables, our approach is limited to the streams of 7 or more members, only. Also we give the results of the numerical example, which shows that the mean values obtained by our approach differ slightly from those obtained by the traditional averaging. However for some streams and for some particular orbital element the differences can exceeds 2 AU in the semi-major axes or 0.5º in the angular orbital elements.

Kehoe, Thomas - University of Florida
Dermott, Stanley - University of Florida
Espy, Ashley - University of Florida
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Title: Dynamical evolution of asteroidal dust particles and their orbital element distribution in near-Earth space

Abstract: A good understanding of the distribution of asteroidal dust in the inner solar system is critical for producing accurate models of the overall dust environment in near-Earth space. Previous investigations of the orbital evolution of dust from asteroidal sources have, however, typically been limited to considering small particles (< 100 microns in diameter) because of their shorter Poynting-Robertson (P-R) drag timescales and hence shorter integration times. With advances in both readily available processing power and numerical techniques, these computational restrictions have now been significantly reduced. Here, we present results from an ongoing investigation into the dynamical behavior of a more realistic size distribution of asteroidal dust particles (up to 1,000 microns in diameter). These simulations have shown that, in contrast to the behaviour of small particles, the orbits of large asteroidal particles (> 100 microns in diameter) are significantly affected by both secular resonances and jovian mean-motion resonances as they slowly decay towards the Sun under the effect of P-R drag. We also discuss the role of interactions with Mars on the distribution of asteroidal dust particles and consider the implications of this work for models of the dust environment in near-Earth
space.

Kornos, Leonard - Department of Astronomy, Physics of the Earth and Meteorology, Faculty of Mathematics, Physics and Informatics, Comenius University Bratislava, Slovak Republic
Toth, Juraj - Department of Astronomy, Physics of the Earth and Meteorology, Faculty of Mathematics, Physics and Informatics, Comenius University Bratislava, Slovak Republic
Corresponding Email: kornos@fmph.uniba.sk

Title: Orbital evolution of Pribram and Neuschwanstein

Abstract: The orbital evolution of two meteorites with very similar orbits and also several thousands of clones were studied in the N-body problem for 5000 years in the past. Meteorites were on very similar orbits during the whole investigated interval. We have searched for photographic meteors and NEOs moving in similar orbits. We have found 5 meteors from IAU MDC database (Lindblad et al., 2005) and 6 NEO with current similar orbits compared to Pribram and Neuschwanstein. Only one meteor 0161E1 and one asteroid 2002 QG46 have similar orbital evolution in the last 2500 and 1500 years, respectively.

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Title: Multi-station video observation of minor meteor streams

Abstract: Multiple-station video observations of major and minor meteor showers have been systematically performed since June 2006 within the framework of the SPanish Meteor Network (SPMN). For this purpose, three automated video stations supported by Universidad de Huelva have been set up in Andalusia. These are endowed with high-sensitivity wide-field video cameras that achieve a meteor limiting magnitude of about +3. The new stations have increased the coverage performed by the low-scan all-sky CCD systems operated by the SPMN. Wide field video systems also provide a time accuracy of 0.1s for determining the appearance of meteor and fireball events. This work is focusing in an overall description of the activity of several meteor showers observed during the first year of operation of the SPMN video stations. Particularly, our present efforts are specially focused in obtaining accurate heliocentric orbits to link these meteoroid streams with their progenitor bodies. Our research program is particularly focused in the coverage of scarcely-known minor meteoroid streams. In addition, a new software package is being developed by the SPMN in order to help with the analysis of the huge amount of data recorded so far.

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Title: Meteoroid Orbit Determination - A need for consensus(!/?)

Abstract: Studies of meteoroid ablation in planetary atmospheres serve as a proxy for determining the compositional make up of the parent bodies of these meteoroids. Spectral observations have revealed clear, and sometimes extreme, variations in the constituent elements of meteoroids (Borvicka et al. 2005, Kasuga et al. 2005, Pellinen-Wannberg et al. 2004). Although most of the major meteor showers have already been

associated with known parent bodies, the acquisition and improvement of accurate orbital data is needed for both taxonomic and scientific reasons (Ryabova 2005, 2007; Jenniskens 2007). To this end the first EuroPlaNet Strategic Workshop on Meteoroid Orbit Determination was held in Roden, The Netherlands, in September 2006. The aim of this workshop was to bring together groups working on orbit determination, from data-collecting observers, through data-analysing programmers to data-using professionals, with a view to improving the techniques used in extracting orbits from observational data. It sought to summarize the work being carried out by the different groups, highlight the main areas in which work needs to be done, and outline steps to be taken in the future to improve meteoroid orbit determination. Here we will present in detail the results of workshop and the work of the Meteoroid Orbit Determination Working Group (MODWG) to date.

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Meisel, David D. - SUNY Geneseo, Geneseo, NY, USA
Pellinen-Wannberg, Asta - Swedish Institute of Space Physics, Kiruna, Sweden
Wannberg, Gudmund - EISCAT Scientific Association, Kiruna, Sweden
Westman, Assar - EISCAT Scientific Association, Kiruna, Sweden
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Title: Meteoroid orbit calculations from tristatic EISCAT UHF measurements

Abstract: The tristatic EISCAT 930 MHz UHF system is used to determine the absolute geocentric velocities for meteoroids detected by all three receivers simultaneously. In these cases, precise radiant information is obtained at the height of the common radar volume. The data used in this study was taken between 2002 and 2005, during four 24 hour periods at summer/winter solstice, vernal and autumnal equinox to locate the largest seasonal difference. The location of the radar system is such that the north ecliptic pole is at zenith once every 24 hours, i.e., during each observational period. This provides ample opportunities to observe off-ecliptic meteoroids and about 30% of the meteoroids have greater orbital inclination than 45 degrees. The observed characteristics of the detected meteoroids are integrated back through the earth's atmosphere to find the meteoroids' above-atmosphere-velocity using an ablation model and the MSIS-E-90 atmosphere model. From the above-atmosphere-velocities, orbits have been calculated for 400 meteoroids. The orbit calculations are performed by taking zenith attraction, earth rotation as well as obliquity of the ecliptic into account. The results are presented in the form of different orbital characteristics.

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Veres, Peter - Department of Astronomy, Physics of the Earth and Meteorology, Faculty of Mathematics, Physics and Informatics, Comenius University Bratislava, Slovak Republic

Komar, Ladislav - Department of Astronomy, Physics of the Earth and Meteorology, Faculty of Mathematics, Physics and Informatics, Comenius University Bratislava, Slovak Republic
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Title: Motion of a meteoroid released from an asteroid

Abstract: Evidence of asteroid surface features as regolith grains and larger boulders implies resurfacing possibility due to external forces, as it is gravitational tidal force during close planet encounters. Motion of a meteoroid released from an asteroid in the gravitational fields of the asteroid and the Earth, is modeled. Asteroid is considered as a spherical rotating body. The meteoroid is initially at rest on the asteroid. They are encountering the Earth. The initial conditions are that the asteroid is at an effectively infinite radial distance vec{r} from the planet and is moving at velocity vec{v} along a line that misses the center of the planet by a perpendicular distance b. We are interested mainly in a distance between the meteoroid and the asteroid, as a function of time. Dependences on b, vec{v} are investigated. The collision cross section for the meteoroid, with respect to the Earth, is calculated and compared with that for the asteroid. Applications to Itokawa will be presented.

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Froeschlé, Claude - OCA, Nice, France
Jopek, Tadeusz J. - Astronomical Observatory UAM, Poznan, Poland
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Title: The spreading of meteoroid streams induced by close planetary encounters

Abstract: Starting from the extension of Opik's theory of close encounters developed by Valsecchi, Milani, Gronchi and Chesley (Astron. Astrophys. 408, 1179, 2003), we compute the perturbation induced by an encounter with a planet on a model meteoroid stream, described by the variables defined in Valsecchi, Jopek and Froeschlé (Mon. Not. R. Astron. Soc. 304, 743, 1999). The formulae so deduced can be used to compute the rate at which a stream is dispersed by planetary encounters into the sporadic background.

SESSION 3: POSTERS
(by alphabetical order)

P25

Abe, Shinsuke - Kobe University, Japan
Nakamura, Takuji - Kyoto University, Japan
Sato, Toru - Kyoto University, Japan
Mann, Ingrid - Kobe University, Japan
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Title: Radar and Optical Observations of Interstellar Meteors

Abstract:
In order to investigate precise determination of the directions of interstellar meteoroids, a powerful VHF Doppler radar observation was carried out. The MU radar is a pulse Doppler radar operating 46.5 MHz,and is equipped with an active phased array antenna of 100 m size and 1 MW peak output power. We carried out using an image intensified CCD video camera with f=200 mm lens simultaneously with radar observation, which was sensitive in +10 magnitude for meteors. We will present detected interstellar meteoroids and discuss about influx of the interstellar dusts.

P26

Cooke, William J. - NASA Meteoroid Environments Office, Marshall Space Flight Center, USA
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Title: The ALTAIR Meteor Measurements Program

Abstract: Established in late 2006, the Meteor Measurements Program is in the process of using the ALTAIR radar located on Kwajelein Atoll to obtain radar observations of sporadic and shower meteoroids. The goals are to determine meteoroid masses, orbits, ballistic coefficients and densities, which shall be provided to the Meteoroid Environment Office (MEO) at Marshall Space Flight Center. These data and analyses shall then be used by the MEO to 1) Add a realistic density distribution to the new Meteoroid Engineering Model (MEM), which is the specified environment for vehicle design in the NASA Constellation (return to Moon) program. This program is the implementation of President Bush's Vision for Space Exploration (VSE). 2) Investigate the meteoroid velocity distribution at smaller masses. 3) Strive to understand the differences (biases) in meteoroid observations produced by systems like ALTAIR and those of the meteor patrol radars, such as the University of Western Ontario's CMOR system. This paper outlines the program details and its progress

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P27

Docobo, José A. - OARMA, Universidade Santiago Compostela
Trigo-Rodríguez, Josep M. – Institute of Space Sciences (IEEC-CSIC)
Borovicka, Jiri - Ondrejov Observatory
Tamazian, V.S. - OARMA, Universidade Santiago Compostela
Fernández, Vera A. - Universidade Coimbra and University of Manchester
Llorca, Jordi - INTE, Universitat Politècnica de Catalunya
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Title: March 1, 2005 Daylight Fireball over Galicia (NW of Spain) and Portugal. A case study for obtaining trajectory data from fireball eyewitnesses.

Abstract:
A daylight bolide was observed over Galicia (the NW region of Spain) and northern Portugal on March 1, 2005 at 15h10m±3m UTC. We have studied this event in the framework of the Spanish Fireball Network (SPMN) using data mainly compiled by the Observatorio Astronómico Ramón María Aller (Univ. Santiago de Compostela). Despite that only visual reports were available, we interviewed numerous eyewitnesses in order to perform measurements of the azimuth and altitude points of the fireball's trajectory by using a theodolite. Twenty three different observations were studied and statistically weighted in order to reconstruct the atmospheric trajectory. The fireball's deepening at an atmospheric height below 20 km suggests that meteorite survival is likely. A first expedition to the probable impact area has been unsuccessful, partly due to the dense forest. However, from the reconstructed trajectory and the fireball's duration, we got a range of probable heliocentric orbits for the progenitor meteoroid. For an entry velocity over 20 km/s the object would be coming from the asteroid belt. This interesting event allow us to discuss procedures involved and information needed from fireball eyewitnesses in order to get reasonable trajectory data.

P28

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Title: A symplectic integrator for investigating dynamics of dust particles.

Abstract: The detailed study of the evolution of meteoroid streams and the migration of dust in the Solar system needs integrating many thousands of orbits. A new effective method of symplectic untegrations is developed for the study of the perturbed Keplerian motion. It is based on separating the Hamiltonian equations of motion for each object in the N-body problem. This allows one to employ individual adaptive time-steps in computations. The integrator can handle both high-eccentricity orbits and close encounters with planets. The numerical algorithm is well adapted for parallel integrations. Applications of this integrator to the studies of the formation of meteoroid streams and the migration of dust particles from the outer Solar system to the inner planetary region are discussed. This work was supported by RFBR-Ural Grant 07-02-96002.

P29

Espy, Ashley - University of Florida
Dermott, Stanley - University of Florida
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Title: Asteroidal Contribution to the Zodiacal Cloud

Abstract: The source of the Zodiacal Cloud has been debated for years. We know from observations that it must have asteroidal and cometary components, but in what relative proportions? The asteroidal component is linked dynamically to the dust bands, which are a fine structure component superimposed on the broad background cloud and can be modeled using the orbital evolution of the dust particles resulting from the breakups of the families that created them. The dust bands are constrained outside 2 AU, due to the secular resonance dispersing the dust band particles into the background cloud, and thus represent only a fraction of the dust contributed to the cloud by the asteroid families associated with them. Determining how this dust evolves inwards of 2AU is the key to deciphering what fraction of the dust in the background cloud is contributed by asteroidal sources. These dust particles will evolve in past the orbit of Mars under the effect of P-R drag, but to what extent will their orbits be affected by any interaction with the planet? The role of this interaction on the dust particle orbits and the overall effect on the asteroidal dust population in the background cloud will be investigated.

P30

Hajdukova, Maria - Astronomical Institute, Slovak Academy of Sciences, Bratislava, Slovakia
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Title: Hyperbolic meteor orbits in the IAU Meteor Data Center catalogues

Abstract: The hyperbolic meteor orbits among the 4581 photographic and 62906 radar meteors catalogued the IAU MDC have been analysed using statistical methods. It is shown that the vast majority of hyperbolic orbits has been caused by the dispersion (reaching the value of ?v~10km/s) of determined velocities. A large proportion of hyperbolic orbits among the known meteor showers, and also the fact that hyperbolic meteors follow the distributions of orbital parameters of all the meteors and show typical interplanetary behaviour, strongly suggest that the hyperbolicity is only formal. It is shown that the number of apparent hyperbolic orbits increases inversely proportional to the difference between the heliocentric velocity of meteoroids and the parabolic velocity limit. The hyperbolicity is caused by a high spread in velocity determination, shifting a part of the data through the parabolic limit. The number of hyperbolic meteors in the investigated catalogues does not in any case represent the real number of interstellar meteors in observational data. The hyperbolicity of 90% of these orbits is only a consequence of measurement errors in velocity determination; however they are, in fact, interplanetary particles.

ℙ31

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Title: Meteoroid stream searching: the use of the vectorial elements.

Abstract: We propose a new distance function D_V (D-criterion) involving the heliocentric vectorial orbital elements. Its first component measures the difference between the angular momentums, the next one includes: the difference between the eccentricities and the difference between directions of the lines of apsides of the orbits. The last term gives the difference between the orbital energies. All components are weighted depending on their dispersion during the evolution of a typical stream. In comparison with the widely used D_{SH} criterion of Southworth & Hawkins, D_D criterion of Drummond, the new function contains two invariants with respect to the principal secular perturbation affecting meteoroid orbit: the orbital energy and the z-component of the angular momentum. The new function proved to be useful in the classification of the meteoroids. We describe the results of the searching amongst the 4097 photographic meteors taken from the IAU2003 Data Center. Using the same reliability level, together with D_V two another D-criteria were applied: D_{SH} and D_N given by Valsecchi et al. For major streams the results are in the very good agreement. In case of minor streams and for near-elliptical streams the results differ markedly.

ℙ32

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Title: The parent bodies of the Quadrantid meteoroid stream

Abstract: We attempt to prove or disprove the comet 96P/Machholz and asteroid 2003 EH1 as the parents of the Quadrantids. For the moments of several perihelion passages of each considered parent-body candidate, we model the theoretical streams around the orbit of the candidate and, via a numerical integration, analyse the dynamical evolution of these streams. The theoretical results are compared with the real photographically detected Quadrantids. It is proved that at least one of 96P and 2003 EH1 is the parent body of the Quadrantid meteor stream. However, it is impossible to decide which one of these two bodies is the dominant supplier of the meteoroids into the stream or whether both these bodies are equivalent. Some ways and means are discussed. Moreover, we investigate a possibility of an existence of a common progenitor of 96P and 2003 EH1, which could split in the past.

P33

Kanuchová, Zuzana - Astronomical Institute of the Slovak Academy of Sciences
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Title: A fine structure of the Geminids

Abstract: A fine structure of the Geminid meteoroid stream in the range of photographic magnitudes is studied using the method of indices a procedure based only on mathematical statistics. A new completed 2003 version of the IAU Meteor Data Center Catalogue of 4581 photographic orbits (Lindblad et al., 2005) is used. The method of indices was used both to acquire a basic data set for the Geminids (Kanuchova and Svoren, 2006) and also to study their structure. A new, more objective method of definition of limits among the groups of associations was used. Sixty four percent of the selected Geminids are grouped in one of the 16 determined filaments of orbits. A structure of the filaments and its connection to the probable parent body (3200) Phaethon is studied.

P34

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Title: Kinematical parameters of 80 September meteors

Abstract:
Kinematical parameters of 80 faint meteors observed in September 2001 and 2003 are presented. High-sensitive TV systems of super-isocon type equipped by photographic lenses Helios-40 (F = 85 mm, D:F = 1:1.5, field of view is nearly of 16 degrees, sensitivity by stars is 11-11.5 stellar magnitude) were used. Trajectory parameters in Earth atmosphere and heliocentric orbital elements were calculated. Errors of all calculating parameters were determined using Monte-Carlo method. The analysis of obtained data is done. Statistical distributions of beginning and end heights of meteors are plotted.

P35

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Kero, Johan - Swedish Institute of Space Physics, Kiruna, Sweden
Szasz, Csilla - Swedish Institute of Space Physics, Kiruna, Sweden
Sidorov, Vladimir - Kazan State University, Kazan, Tatarstan, Russia
Briczinski, Stan - Penn State University, State College, PA, USA
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Title: Physical Characteristics of Kazan Microshowers As Determined by Correlations with the Arecibo UHF Radar

Abstract: In the northern hemisphere, the month of February is characterized by a lack of major meteor shower activity, yet a number of weak "microshowers" are present as seen by the Kazan radar. Using the Feller transformation to obtain the distribution of true meteor velocities from the distribution of radial velocities enables the angle of incidence to be obtained for the single beam AO data. Thus the loci of AO radiants become beam centered circles on the sky and one can with simple search routines find where these circles intersect on radiants determined by other means. Including geocentric velocity as an additional search criterion, we have examined a set of February radiants obtained at Kazan for coincidence in position and velocity. Although some may be chance associations, only those events with probabilities of association > 0.5 have been kept. Roughly 100 of the Kazan microshowers have been verified in this way with mass, radius and density histograms derived from the AO results. By comparing these histograms with those of the "background" in which the microshowers are found, a qualitative scale of dynamical microshower age can be formulated. Most of the microshowers are found outside the usual "apex" sporadic source areas where it is easiest to detect discrete showers with less confusion from the background.

P36

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Title: Large dust grains around cometary nuclei

Abstract: Large amounts of particles ejected from the nucleus surface are present in the vicinity of the cometary nuclei when comets are near the Sun (at heliocentric distances < 2 AU). The largest dust grains ejected may constitute a hazard for spatial vehicles. We tried to obtain the bounded orbits of those particles and to investigate their stability along several orbital periods. The model includes the solar and the cometary gravitational forces and the solar radiation pressure force. The nucleus is assumed to be spherical. The dust grains are also assumed to be spherical, and radially ejected. We include the effects of centrifugal forces owing to the comet rotation. An expression for the most heavy particles that can be lifted is proposed. Using the usual values adopted for the case of Halley's comet, the largest grains that can be lifted have a diameter about 5 cm, and the term due to the rotation is negligible. However, that term increases the obtained value for the maximum diameter of the lifted grain in a significant amount when the rotation period is of the order of a few hours.

P37

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Yoshikawa, Makoto - JAXA/ISAS
Watanabe, Junichi - NAOJ
Hidaka, Eiji - Tokyo Meteor Network
Murayama, Hideyuki - Tokyo Meteor Network

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Title: Jovian impulses acting upon the Quadrantid meteor stream

Abstract: The Jovian impulses, acting upon some part of the Quadrantid meteor stream around its aphelion, are important mechanics for the orbital motion of the Quadrantids as well as the secular and resonant perturbations, since the Jovian impulses might drive the orbital evolution rapid. We have several orbital data of the Quadrantids which indeed encountered Jupiter at half
an orbital period before their observations. Integrating their orbital motions backward for more than 100 yr, we studied their evolutional behavior characteristic analytically and numerically.

P38

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Title: Lyrid meteoroid stream: orbit and structure

Abstract: A fine structure of the Lyrid meteor stream based on photographic orbits available in the IAU Meteor database is studied. Seventeen Lyrids were found in the database. We have searched for potential sub-streams to be associated with the stream utilizing Southworth-Hawkins D-criterion. Applying a stricter limiting value for D, two independent filaments pertinent to the stream could be separated. To confirm their mutual consistence as filaments, their orbital evolution over 5000 years is investigated. The evolution of the nodes of all the orbits is also analysed. We have also searched for NEAs to be possibly associated with the mean stream of the Lyrids and the two filaments. The results are discussed and confronted with the previous analyses.

P39

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Hajrov, T.N. - Kazan State University
Nasyrov, A.F. - Kazan State University
Sidorova, S.V. - Kazan State University
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Title: Orbital structure of visible meteoric complex according to long-term radar monitoring. Direct and retrograde orbital movement.

Abstract: In 1986-2002 radar observation for long-term monitoring of meteoric substance have been done in Kazan. Technical features of experiment: high power radar provided registration of big number of meteors, radar goniometer provided resolution 1dgr. The review of celestial sphere was reached due to rotation of directed aerials and daily Earth's rotation. Measurements of meteor speeds were done by diffraction method providing an error of measurement not worse than 3km/s. The discrete-

quasitomographic method of goniometric data analysis, based on microshower hypothesis, provided angular resolution of radiants not worse 2dgr. The feature of the method is that average parameters of microstream orbits were defined with the number of measurements in every microstream begining from 6 meteors per/day. Large meteoric streams have been submitted by orbits of partial streams. Orbital elements of 2200 microstreams covering full annual cycle of observation with identical conditions of registration of minimally registered weights and correction for zenith attraction are determined. 3D-and-4D-dimensional maps of distribution of microstreams with numbers of meteors and density of falling stream in them by inclinations and longitudes of ascending nodes, by perihelion coordinates, by perihelion
and aphelion distances are constructed. Seasonal changes of microstream visibility separately for direct and retrograde orbits are investigated.

ℙ40

Svoren, Ján - Astronomical Institute of the Slovak Academy of Sciences
Neslušan, Luboš - Astronomical Institute of the Slovak Academy of Sciences
Porubkan, Vladimír - Astronomical Institute of the Slovak Academy of Sciences
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Title: Current status and a call for a new version of the database

Abstract: A central depository for meteor orbits obtained by photographic techniques as a part of the IAU Meteor Data Center, was moved to the Astronomical Institute of the Slovak Academy of Sciences in Bratislava in 2001. The first result of the new management was publishing data on 4581 meteor orbits obtained by 17 different stations or groups from the period 1936-1996 (Lindblad et al, 2003). This version of the database is available at the homepage of the Astronomical Institute, Slovak Academy of Sciences:
http://www.astro.sk/~ne/IAUMDC/Ph2003/database.html
Since 1996 a few huge campaigns were organised including very succesful Leonids and Perseids. That is why we would prepare a new more complete version of the database. The main aim of this paper is a call to the observers of meteors having new or recalculated/remeasured data on photographic meteors to send them to the MDC, where after a check and consultations with the observer, the orbits will be included in the database. A final version of the IAU MDC photographic meteor orbits is supposed to be published sometimes in 2009-10.

Session: 4:
METEOROIDS INTERACTIONS WITH ATMOSPHERES

INVITED TALKS
(by alphabetical order)

Dyrud, Lars - Center for Remote Sensing Inc.
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Close, Sigrid - LANL
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Title: Plasma and EM simulations of meteor head echo radar reflections

Abstract: Every day billions of meteoroids impact and disintegrate in the Earth's atmosphere. Current estimates for this global meteor flux vary from 2000-200,000 tons per year, and estimates for the average velocity range between 10 km/s to 70 km/s. The basic properties of this global meteor flux, such as the average mass, velocity, and chemical composition remain poorly constrained. We believe much of the mystery surrounding the basic parameters of the interplanetary meteor flux exists for the following reason, the unknown sampling characteristics of different radar meteor observation techniques, which are used to derive or constrain most models. We believe this arises due to poorly understood radio scattering characteristics of the meteor plasma, especially in light of recent work showing that plasma turbulence and instability greatly influences meteor trail properties at every stage of evolution. We present our results on
meteor plasma simulations of head echoes using particle in cell (PIC) ions, which show that electric fields strongly influence early stage meteor plasma evolution, by accelerating ions away from the meteoroid body. We also present the results of finite difference time domain electromagnetic simulations (FDTD), which can calculate the radar cross section of the simulated meteor plasmas. These simulations have shown that the radar cross section depends in a complex manner on a number of parameters. These include a relatively weak dependence on angle between radar and meteor entry, a large dependence on radar frequency, which shows that for a given meteor plasma size and density, the reflectivity as a function of probing radar frequency varies, but typically peaks below 100 MHz. We present functional forms for the RCS of head echoes as a function of plasma parameters such as peak plasma density and size. Finally, we will discuss how this parameterization of head echo RCS can be used to derive meteoroid, and meteor ablation, ionization, and plasma properties from HPLA head echo observations.

Genge, Matthew J. – Imperial College London
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Title: The nature and diversity of micrometeorites

Abstract: Micrometeorites (MMs) are extraterrestrial dust particles >50 microns that have survived atmospheric entry to be recovered from the Earth's surface. These

materials provide a sample of low-geocentric velocity, sub-cm micrometeoroids for study in the laboratory. In the current paper the mineralogical and chemical diversity of micrometeorites recovered from Antarctic ice is presented. The MMs can be subdivided into fine-grained and coarse-grained particles. Fine-grained micrometeorites are broadly similar to the matrices of CI and CM carbonaceous chondrites (CCs), since they are dominated by clay-minerals and their thermal decomposition products. In detail, however, their mineralogy is differs from CCs suggesting that their asteroidal parent bodies include different objects to meteorites. Coarse-grained MMs are dominated by igneous materials with mineralogical, textural and chemical similarities to chondrules, mm-sized igneous objects from chondritic meteorites. The majority of coarse-grained MMs have minor element chemistries similar to chondrules from ordinary chondrites. Unambiguous differentiated particles are exceedingly rare. The presence of composite particles containing fine-grained and coarse-grained portions supports the interpretation of coarse-grained MMs as chondrule fragments and suggests that low-velocity micrometeoroids may be composed of components of very different mechanical strength on mm-scales. Micrometeorite diversity suggests there are at least three major classes of parent body.

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Title: Models of meteoroid fragmentation

Abstract: Fragmentation is a very important phenomenon, which occurs during the meteoroid entry into the atmosphere. Fragmentation affects observed meteor parameters and is responsible for many differences between single-body predictions and observations. Numerous studies have been carried out to show the influence of fragmentation on light curves, deceleration, radar echoes, initial radius of meteor train for small meteoroids. Different models (dustball, grain etc) were proposed. There are different ways to estimate the conditions for meteoroid breakup in the atmosphere. For larger meteoroids most of approaches model the breakup under aerodynamic loading. Breakup events can be determined from bolide data by geometric, dynamic or photometric method. Bolide fragmentation can be studied also from acoustic/seismic data. Different fragmentation models were applied for large meteoroids (progressive fragmentation, gross-fragmentation, FM etc). This presentation will review existing fragmentation models and will discuss model boundaries and open questions.

SESSION 4: ORAL CONTRIBUTIONS
(by alphabetical order)

Barri, Natalia G. - Institute of Mechanics, Moscow State University, Russia
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Title: Transverse scattering of meteoroid fragments in the atmosphere

Abstract: The transverse scattering of meteoroid fragments in the supersonic flow has been investigated. The fragments transverse force originates from shock waves interaction. The model of meteoroid fragments separation by layers has been proposed. Each fragment is considered as an individual solid. The analytical solution of the dynamic equation is used for modeling where the transverse force dependence on the distance between fragments is taken into account. It is discovered that the transverse scattering time to the point where the interactions stop is significantly shorter than total time of meteoroid movement in the atmosphere and practically does not depend on the number of fragments according to the proposed model.

Fentzke, Jonathan - NorthWest Research Associates Inc., CoRA Division | Department of Aerospace Engineering Sciences, University of Colorado at Boulder
Janches, Diego - NorthWest Research Associates Inc., CoRA Division
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Title: A semi-empirical model of the contribution from sporadic meteoroid sources on the meteor input function observed at Arecibo

Abstract: Microgram extraterrestrial particles from the sporadic background are widely believed to be the major contributors of metals in the Mesosphere/Lower Thermosphere (MLT). It is well established that this material gives rise to the upper atmospheric metallic and ion layers observed by radars and lidars. In addition, micrometeoroids are believed to be an important source for condensation nuclei (CN), a prerequisite for the formation of NLC particles in the polar mesopause region. In order to understand how this flux gives rise to these atmospheric phenomena, accurate knowledge of the global meteoric input function (MIF) is critical. In this paper, we present results from a detailed model of the diurnal and seasonal variability of the micrometeoric activity in the MLT as observed by the 430 MHz Arecibo radar. The model uses Monte Carlo simulation techniques and includes an accepted mass flux provided by six main known meteor sources (i.e. orbital families of dust) and a detailed modeling of the meteoroid atmospheric entry and ablation physics. The principal goal of this effort is to construct a more precise sporadic MIF needed for the subsequent modeling of the atmospheric chemistry of meteoric material and the origin and formation of metal layers in the MLT.

Hawkes, Robert L. - Physics Department, Mount Allison University, Sackville, Canada
Milley, E.P. - Physics Department, Mount Allison University, Sackville, Canada

Ehrman, J.M. - Digital Microscopy Facility, Mount Allison University, Sackville, Canada
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Title: What can we learn about atmospheric meteor ablation and light production from laser ablation?

Abstract: Laboratory based laser ablation techniques can be used to better determine the heat transfer coefficient at different energy flux values, the luminous efficiency factor, and the role of chemically differentiated thermal ablation. A 10 pps , 15 mJ per 10 ns pulse Nd:YAG laser (frequency doubled to 532 nm output) was used to ablate regions from ordinary and carbonaceous chondrite meteorites. A scanning electrón microscope (SEM) was used to characterise the area and depth of the ablated pits. A colour CCD and a digital spectroscope were used to measure the size and spectrum from the cloud of vaporised material. The optical spectroscopy indicated emission lines of Ca, Fe, Mg, Na, N, O and Si, with lines from both neutral and singly ionised species present. There was also an indication of either unresolved spectral lines or continuum emission. Energy dispersive x-ray spectroscopy (EDS) with the SEM can be used to evaluate elemental abundance before and after ablation to assess the importance of differential ablation. This paper will provide an overview of the potential of the technique, early results in some of these areas, comments on the limitations of the technique for simulation of meteor ablation conditions, and suggestions for optimisation of a laser ablation facility for meteor work.

Janches, Diego - NorthWest Research Associates/CoRA Division
Fentzke, Jonathan T. - NorthWest Research Associates/CoRA Div. and University of Colorado
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Title: Estimating the meteoric mass flux in the Mesosphere and Lower Thermosphere Atmospheric region

Abstract: The major source of metallic material responsible for a variety of atmospheric phenomena in the Mesosphere and Lower Thermosphere (MLT) originates from the ablation of extraterrestrial particles in the mass range of 10^11 to 10^4 g. The estimated daily amount of meteoric mass deposited globally into the upper atmosphere in this mass range varies by ~2 orders of magnitude (~7 to 250 tons of material a day over the whole planet). Since most of these results were obtained from instruments that lie well above the MLT region, they represent the influx of mass at the very highest extent of the earth's atmosphere. The difference between the mass flux determined outside the Earth's atmosphere integrated globally and annually and that measured at MLT altitudes in a specific location and time is important to model MLT meteor related phenomena. This fact invites further investigation into the instrumentation and data used to derive these mass input functions. In this paper, we discuss a new approach that combines high-resolution radar measurements and a new model of the meteor input function in the upper atmosphere.

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Title: Goals and objectives of the IAU Commission 22's Task Group on Meteor Shower Nomenclature (roundtable)

Abstract: At the 2006 IAU General Assembly in Prague, the Commission 22 has established a Task Group for Meteor Shower Nomenclature with the objective to formulate a descriptive list of established meteor showers that can receive official names during the 2009 IAU General Assembly. The task is to be completed about half a year prior to the 2009 Assembly. Meteor shower nomenclature rules were formulated. These rules and the Task Group's goals and objectives were announced in IAU Bulletin 99, following the meeting. The Task Group will need your help in identifying which meteor showers are established. A working list of ~ 230 candidate showers, codes and IAU numbers, is made available that can serve to facilitate this discussion. In the coming years, this working list will be expanded with newly identified showers and other showers that deserve further scrutiny. The Task Group plans to meet at the Meteoroids 2007 meeting and the presentation will outline, and open to discussion, what criteria are being developed to identify the meteor showers that deserve to be called "established".

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Szasz, Csilla - Swedish Institute of Space Physics, Kiruna, Sweden
Pellinen-Wannberg, Asta - Swedish Institute of Space Physics, Kiruna, Sweden
Meisel, David D. - SUNY Geneseo, Geneseo, NY, USA
Wannberg, Gudmund - EISCAT Scientific Association, Kiruna, Sweden
Westman, Assar - EISCAT Scientific Association, Kiruna, Sweden
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Title: Meteoroid disintegration characteristics in EISCAT HPLA radar observations

Abstract: We present investigations of the characteristics of 400 tristatic meteors detected with the EISCAT 930 MHz radar system and their dependence on meteoroid origin and entry circumstances. Observed velocities and target cross sections are compared with simulations using a numerical ablation model to estimate meteoroid mass, temperature, mass loss, head electrón density and atmospheric entry velocity. Some of the events show observational signatures of fragmentation and/or breakup in or before the meteoroid enters the common volume monitored by all three receivers. The statistical distribution of these events is investigated and discussed.

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Szasz, Csilla - Swedish Institute of Space Physics, Kiruna, Sweden
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Westman, Assar - EISCAT Scientific Association, Kiruna, Sweden
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Title: Three dimensional radar observation of a submillimeter meteoroid fragmentation

Abstract: The EISCAT 930 MHz radar system comprised of three receivers with intrinsic separation of 200-400 km have been used to simultaneously monitor an illuminated volume at 96 km altitude, the peak of the altitude distribution of the system. We present and discuss an example of a meteor event during which the received power of the meteor head echo fluctuates at different rates in the data of the three receivers. We argue that the pulsations are caused by interference between radio wave reflections from two distinct ionized regions caused by a pair of meteoroid fragments simultaneously passing through the common volume monitored by all three receivers. The different rates of the pulsations are consistent with interference patterns produced by two targets traveling along the same trajectory with slightly different deceleration.

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Broadley, Sarah L. - School of Chemistry, University of Leeds, Leeds LS2 9JT, UK
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Janchez, Diego - NorthWest Research Associates, CoRA Division, Boulder, Colorado, USA
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Title: Differential ablation of meteoroids a thermodynamic equilibrium model

Abstract: Observations of background metal layers and fresh meteor trails in the MLT (mesosphere-lower thermosphere) region indicate that constituent elements (Si, O, Fe, Mg, Na, K, Ca) are released at different altitudes with different efficiencies, and possibly in different chemical states. We report a new ablation model based on the calculation of chemical equilibrium in the melted meteoroid particle, between the melt and the vapor and in the gas phase. The chemical equilibrium is calculated by the mass action, mass balance MAGMA [L.Schaefer and B.Fegley Jr., Icarus 169 (2004)216241] code. The particle mass loss rate is derived from the vapor pressure using the Langmuir evaporation formalism. The model predicts maximum Fe ablation at ~85 km for the LDEF meteoroid mass and velocity distribution. The alkali metals Na and K ablate approximately 10 km higher. We consider particles of a range of densities. The model is then used to explore multiple lidar observations of meteor trails, and to explain the substantial depletion of group 2 elements (Mg, Ca) relative to alkali metals. Chemical composition of the ablated mass is used to calculate the electron line density, and the dependence of the meteor head echo on particle size and velocity

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Suzuki, Satoshi - Nippon Meteor Society
Maeda, Kouji - Nippon Meteor Society
Higa, Yoshihiro - Nippon Meteor Society
Toda, Masayuki - Nippon Meteor Society
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Title: Invisible persistent trains generated by Geminids

Abstract: Studies on meteor trains have been extremely evolved in this decade after encountering the Leonid meteor storms during 1998-2002, however, meteor train studies by the other meteor swarms are seldom reported. Here we present the recent research results of persistent meteor trains of the Geminids. As a result of successful collaboration with amateur meteor observers in Japan, fruitful imaging results about Leonid persistent trains were archived by the METRO (MEteor TRain Observation) campaign. After having this great success in triangulation imaging, we applied the observation technique to the other meteor swarms, resulting in discovery of invisible persistent trains generated by Geminid meteors. In the period of 1998-2004, unexpected results of 40 image sequences of the Geminid persistent trains with 2 triangulation observations were obtained. Based on these datasets, there seems to be a lack the second phase of persistent train luminescence mechanism of Leonid case shown in a paper by Koten et al. (2003), arising interesting feature of persistent trains by a non-comet-like parent body of the Geminids.

SESSION 4: POSTERS
(by alphabetical order)

ℙ41
Bass, Elizabeth - Boston University
Oppenheim, Meers - Boston University
Chau, Jorge - Jicamarca Radio Observatory
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Title: Improving the Accuracy of Mass Estimates from Meteor Head Echo Deceleration

Abstract: High-power, large aperture (HPLA) radar observations of meteors were taken in July 2005 using the 50MHz antenna at the Jicamarca Radio Observatory (JRO) in Peru. This data set has the highest resolution in time and range currently possible with that radar. This poster presents a study of how accurately meteor mass can be determined from this type of high-resolution HPLA observations. To do this, meteor simulations were used to determine the expected mass loss, deceleration, and temperature changes along a meteoroid's trajectory. After estimating the meteor ionization rate and radar reflection strength, then noise was added in such a way that these synthetic signals mimicked real radar data. We then compare these simulated meteors with the JRO observations. Different algorithms were employed to process both the simulated and real signals in an effort to investigate which techniques are the most accurate to calculate meteor mass and to what degree.

ℙ42
Gritsevich, Maria - Institute of Mechanics, Moscow Lomonosov State University, Moscow, Russia
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Title: New method for entry dynamics determination upon observations

Abstract: Now a big actual material on photographic registration of meteoric bodies trajectories in the Earth's atmosphere is accumulated. The greatest number of pictures is made by the four fireball networks which functioned at various times in the USA, Canada, the Europe and Spain. Approximation of real data by theoretical dependencies allows to receive the additional estimations which are not following directly from observations. Here the algorithm of selection of parameters, at which the theoretical dependence of height on speed in the best way approximates data of observations, is offered. The basic difference from previous works is approach of the set points by the analytical solution of the meteoric physics equations. The method was applied to some bright meteors from the Canadian network, Prairie network, and also to the Beneshov bolide, one of the largest, registered by the European network. Correct mathematical modeling of the meteoric phenomena in an atmosphere is necessary for the subsequent estimation of key parameters: extra-atmospheric mass, ablation coefficient, effective enthalpy of evaporation. In turn, these data are important for some appendices - researches of asteroid-comet hazard, measures of planetary defense, and also for search of the bodies, capable to reach the Earth's surface.

ℙ43

Gritsevich, Maria - Institute of Mechanics, Moscow Lomonosov State University,
Stulov, Vladimir *- Institute of Mechanics, Moscow Lomonosov State University,
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Title: Initial mass of the Neuschwanstein fireball

Abstract: The model of the atmospheric entry of the Neuschwanstein fireball is developed. The fireball was photographed in Germany on 6 April, 2002. Three fragments of a meteoric body were found during the subsequent searches in the territory predicted in observation. In this work the form of a meteoric body is set as a cube with the rounded tops and edges. The estimation of the meteoric body mass at its entry into the atmosphere has appeared to be close to the literature data received as a result of the seismic, acoustic and infrasonic analysis. It is noted that for the first time in the analysis of fireball data, the photometric approach usually considered in the world literature was not used.

ℙ44

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Title: Quantitative Comparison of a New Ab Initio Micrometeor Ablation Model with Standard Published Models

Abstract: Because of sputtering and ablation of micrometeoroids at velocities> 20 km/s, accurate meteor orbit determination depends on being able to integrate back through the earth's atmosphere in a consistent and reliable way. An ab initio model of meteor ablation has been devised that works over the mass range 10^{-16} kg to 10^{-7} kg. Among the features of this model are: 1) Uses the vacuum vaporization theory of O'Hanlon (2003) for ablation, 2) uses experimental heat transfer and other parameters measured by Friichtenicht and Becker (1973) and 3) uses a unified synthesis of experimental data for the most important meteoroid elements and their oxides through least square fits(as functions of temperature, density, and/or melting point)of the tables of thermodynamic parameters given in the CRC, AIP Handbook, and Allen's Astrophysical Quantities (2000), 4) uses MSIS model atmospheres, 5) uses the sputtering model of Tielens et al.(1994) as suggested by Rogers et al. (2005). The main comparison will be with a Love-Brownlee model (ultimately based on the work of Opik) but including Tielens et al. sputtering. The new model is being used to reinterpret Arecibo extrasolar micrometeor orbital and size data.

ℙ45

Nazarava, Katsiaryna – Imperial College of London, UK
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Title: Meteoroid strength estimation by numerical modeling

Abstract: Information on the strength of meteoroids over a range of sizes is rather limited. The strength of the body depends on material, structure, composition, dimension, shape, and its life history. Fragmentation of meteoroids by aerodynamic forces is closely connected with their strength – improving models of meteoroid strength is fundamental to an understanding of meteoroid fragmentation, and to improving our understanding of impact rates at planetary surfaces (Bland and Artemieva, 2003). Here we use the model of separate fragments (SF) and a hydrodynamic approximation to estimate the strength of some terrestrial impactors. By varying bolide strength in our simulations of atmospheric disruption, or small-asteroid impact, we can achieve a best-fit to specific fireball events and terrestrial crater fields. The "pancake" model application is shown to the Brno fireball and the separate fragments model application is shown to the Morasko iron shower.

ℙ46

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Title: Modeling and Monitoring Genesis and Stardust Reentries

Abstract: During September 2004 (Genesis experiment) and January 2006 (Stardust experiment), NASA performed two sample return missions into UTTR (Dugway, Utah) while entering over the Pacific Ocean from the northwesterly and westerly directions respectively. During each of these reentries, we participated by monitoring the hypersonic boom corridor pressure waves in an infrasonic pass-band from ~0.02 to 50 Hz with an array of sensors at the airport in Wendover, Nevada. Subsequently, we performed detailed entry modeling analyses on these man-made capsules including the details of drag/deceleration, mass loss, light and sound production, etc., using entry models that have been calibrated on the basis of large bolide interactions with the atmosphere. In addition, we also analyzed the infrasonic data using digital cross-correlation, FFT-based, beam-forming techniques and have ray traced the "line-source" signals from the blast region downward using detailed, realistic model atmospheres including air
temperature variations with altitude (or equivalently in terms of the sound speed and the mean molecular weight) as well as horizontal winds. We also evaluated and compared the source energies for each case as a function of altitude deduced on the basis of the recorded infrasonic waves with the well-known detailed properties for each of these man-made sources, etc.

ℙ47

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Title: Formation of increased ionization region at high altitudes due to interaction of sputtered meteoroid substance with the atmosphere

Abstract: Formation of disturbed area around fast meteor body at the high altitudes (>120 km) is determined by sputtering. Physical model describing the interaction of ionized sputtered meteor particles with the atmosphere was created. Sputtered ions create ionized meteor trail with the electrón concentrations exceeding the background values. Linear electrón concentrations appear to be high enough to be registered by radiolocation.

ℙ48

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Title: Final decision of the 1908 Tunguska event

Abstract: There were many versions of the 1908 Tunguska event. Here the final decision is developed on the basis of the real motion of a large meteoric body in the Earth's atmosphere. When meteors move in the atmosphere, the relative role of evaporation is characterized by a mass loss parameter. It is shown that the properties of solutions for the main system of meteor physics equations [1], along with the results of the independent numerical experiment [2], provide the conclusion that the well-known Tunguska impact event that happened on June 30, 1908 was a giant micrometeor. It was an ordinary phenomenon that differed from daily micrometeors only in the scale expressed by the huge mass of the meteoric body.

References
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Petersburg, Russia. 3: 82-83 (in Russian).
2. Shuvalov V.V., Artemieva N.A. 2002. Numerical modeling of Tunguska-like impact. Planetary & Space Science 50:181-192.

ℙ49

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Gritsevich, Maria - Institute of Mechanics, Moscow Lomonosov State University< Moscow, Russia
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Title: New initial masses of large fireballs from the Canadian Network

Abstract: In *classical* works the preatmospheric masses of meteoric bodies were defined under the so-called photometric formula by integration of luminosity along a visible sector of the trajectory. On the other hand, the mass of a meteoric body characterizes height and intensity of meteor braking in the atmosphere. In a number of works the

essential divergence of values of the masses received by these two ways was marked. Practically always the photometric masses on the order and more exceed the masses defined on braking intensity. In this work, the preatmospheric masses are defined by selection of the parameters describing braking and ablation of meteors along all visible sector of their trajectories. The basic result of calculations for fireballs from the Canadian network consists in essential difference of the initial masses defined by braking on all observable site of a trajectory, on the one hand, and the masses received from intensity of a fireball luminescence (photometric masses), on the other hand. There is neither enigma nor dilemma in distinction of photometric and dynamic masses of a meteoric body. There is a mistake in compulsory and formal, non-physical use of communication between a luminescence and change of mass along its trajectory.

ℙ50

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Westman, Assar - EISCAT Scientific Association, Kiruna, Sweden
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Title: Luminosity of the EISCAT UHF micrometeoroids estimated with an ablation model

Abstract: The purpose of this study is to investigate the conditions for simultaneous meteor observations with the EISCAT UHF radar system and telescopic optical devices. The meteor luminosity is calculated as a part of a meteoroid ablation model using a fifth order Runge-Kutta numerical integration technique. The observed characteristics for 400 tristatic meteoroids are compared with model simulations and their luminosity is estimated. The luminosity of our targets gives us a hint of the necessary requirements of an optical device able to detect them. No simultaneous HPLA head echo and optical observations have hitherto succeeded, due to the bw light emission levels of typical HPLA meteors. Having both types of observations of the same meteors would be of great importance in further understanding of the meteoroid-atmosphere interaction processes and the physics of the head echo.

ℙ51

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Shigeno, Yoshihiko - Meteor Science Seminar
Kasuga, Toshihiro - NAOJ
Abe, Shinsuke - Kobe University
Higa, Yoshihiro - NMS
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Title: Height analyses of short-duration meteor trains

Abstract: Meteor train phenomena are mainly categorized into the two parts: short-duration meteor trains and persistent meteor trains at a threshold of about 5 seconds from appearances of parent meteors. We acquired many imaging data of meteor trains at a night of the highest appearance of Leonids in 2001 and opened a way to statistical studies of persistent train (Toda et al, 2003; Yamamoto et al, 2005). However, observation examples of short-duration meteor trains disappearing within about 5 seconds are still quite limited. In order to obtain meteor trajectory data with high accuracy, a series of double-station image-intensified TV observation with high spatial and temporal resolution has been continuously carried out by Shigeno et al. (1992-2006). Recently, the importance of imaging data of short-duration meteor trains has been recognized and we found that the TV observation archives by Shigeno et al. include many useful data for the analyses of short-duration meteor trains because these data has quite precise triangulation results. Altitudinal distribution of short-duration meteor trains has been investigated by using the archives double-station video data for Leonids 2001. In this talk, from the generation process to dissipation, luminescence of short-duration meteor trains is investigated in detail within an altitude range between 120km down to 90km. Since spectroscopic studies of meteor phenomena showed luminescence in the region of mesosphere and lower thermosphere could be statistically revealed by the analyses of short-duration train data.

Session: 5:
ASTROMINERALOGY: COMET 81P/WILD 2 AND COMETARY METEOROIDS

INVITED TALKS
(by alphabetical order)

Borovicka, Jiri - Astronomical Institute of the Academy of Sciences, 251 65 Ondrejov Observatory, Czech Republic
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Pavel Koten - Astronomical Institute of the Academy of Sciences, 251 65 Ondrejov Observatory, Czech Republic
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Title: Properties of cometary dust from meteor observation

Abstract: The first part of the talk will be devoted to the recent analysis of video data of Draconid meteors. Our stereoscopic observations provided not only light curves but also decelerations and wake measurement of seven meteors. All these data were successfully modeled using a simple fragmentation model. The meteoroids of original size from 5 mm to 5 cm and most likely
bulk density about 300 kg/m3 started to disintegrate into individual grains at the heights about 100 km. The disintegration took several tenths of a second. The disintegration energy was 15-30x lower than the ablation energy. The constituent grains had a relatively narrow size range in each meteoroid but some meteoroids were coarse grained with grain size about 100 microns and some were fine grained with grain size about 40 microns. The largest meteoroid, observed also photographically, was fine grained, but some 30% of the mass was not subject to initial gradual disintegration and broke-up suddenly at a height of 84 km. In the second part, cometary meteoroids of different origin will be compared. The composition of cometary dust will be discussed and arguments will be presented that the Fe/Mg ratio is lower in cometary dust than in chondrites.

Flynn, George J. - SUNY-Plattsburgh
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Title: Elemental Composition of Dust Collected at Comet 81P/Wild 2 by NASA's Stardust Spacecraft

Abstract: On January 15th, 2006 NASA's Stardust spacecraft delivered material collected from the dust coma of Comet 81P/Wild 2 to Earth. During the Stardust Preliminary Examination, material along 23 "tracks," produced by impact capture of Wild 2 dust into low-density silica aerogel capture cells, and residue in 7 craters, produced by impact into Al-foil, were analyzed. These analyses indicate the mean elemental composition of the captured material agrees with the composition of CI meteorites, which are believed to represent the bulk composition of the Solar System,

for the refractory elements Mg, Si, Mn, Fe, and Ni to +35%, and for Ca and Ti to +60% (Flynn et al., Science, 314, 1731-1734, 2006). However, the Fe/Si ratio appears to be slightly lower than the CI ratio. In addition, the moderately-volatile elements Cu, Zn, and Ga are significantly enriched over the CI abundances and S appears to be significantly depleted in this
Wild 2 material. The extent to which this Wild 2 material is representative of comets in general is not known. Chemical measurements on cometary meteors, examining the ratio of moderately-volatile to refractory elements as well as the S abundance, could determine if these deviations from CI composition are characteristic of comets.

Rietmeijer, Frans J.M. - University of New Mexico
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Title: Cometary meteors after Sturdust

Abstract: Wild 2 particles are weakly constructed, very low tensile strength, mixtures of mostly nanometer grains with fewer up to ~10 micron grains that include Mg-Fe-[Ca]-silicates, Fe-Ni-sulfides, Fe-Ni-metal, and Ca-Al-[Mg-Ti]-minerals. They are found along track walls and at the termini. Sub-micron debris, Fe-Ni-S phases and silicates, is found embedded and assimilated in silica glass of modified aerogel. I will discuss that Wild's large, massive FeS and FeNi grains cause a bias in the Fe-normalized S and Ca abundances that appear to be depleted, but when its nanometer grains are considered the comet is chondritic. The implications for comet-aggregate meteors could be that (1) non-chondritic meteors are aggregates of mostly large, massive grains and (2) chondritic meteors are dominated by fine-grained dust. Differential ablation mostly affects the elements on refractory mineral grains. I will discuss that for FeS and FeNi-rich comets such as comet Wild, the Fe-normalized Al Ca and Ti abundances might be defined by main component abundances. Higher than CI, Ca in the 2nd component might point to "exceptionally large" grains, highly refractory grains (CaTiAl2O6), or both. Is Wild 2 with its abundant crystalline grains unusual, or is their meteor data to support that Jupiter-family and Halley-type comets are different?

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Title: Combined Micro-IR and Micro-Raman Analyses of Comet 81P/Wild 2 Particles Collected by Stardust

Abstract: We report combined micro-infrared, micro-Raman, and Field Emission Scanning Electron Microscope analyses of particles collected by the Stardust spacecraft during its fly-by of comet 81P/Wild2 on 2 January 2004 and returned back to Earth on January 2006. We present mid-IR spectra of four of these particles. The CH2/CH3 ratios inferred from the infrared data are greater than these seen in organics in the diffuse interstellar medium, possibly indicating the presence of longer or less branched aliphatic chains. The micro-Raman data offer insights on the state of order of the carbonaceous component present in the particles. A comparison with spectra of Interplanetary Dust Particles (IDPs) and meteorites yields for most of the particles analyzed that the cometary carbonaceous material span a similar range to those of IDPs and the most primitive meteorites. Both the IR and Raman data imply labile carbonaceous component, mixed with refractory minerals, that has not been observed in meteorites and IDPs. Hydrated minerals seem to be present in one particle which seem to contain also carbonates, but further investigations with other techniques need to be performed to confirm these findings. The analyses are rendered difficult to interpret because of the presence of aerogel mixed with the grain.

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Title: Structure and composition of cometary meteoroids: clues from comet 81P/wild 2, carbonaceous chondrites, and IDP results

Abstract: Stardust's capture of 81P/Wild 2 cometary meteoroids provides clues on the physical properties, and the chemical and isotopic composition of cometary materials. Particularly, detailed studies on the physics recorded in the deceleration tracks that 81P/Wild 2 meteoroids excavated in Stardust's aerogel can provide information on the structure of cometary aggregates before atmospheric interaction, and new clues on the real amount of organic matter and volatiles that cometary meteoroids are delivering to the Earth. In particular, not only the surviving mineral grains if not also the ablation and sputtering products preserved in the tracks' walls are unique materials that can be compared with recovered Interplanetary Dust Particles (IDPs) in order to better understand the pathways of cometary materials delivery to the Earth, nowadays and in the remote past. The peculiar structure and physical properties of comets and chondritic asteroids in the early solar system environment would convert these bodies and their fragments in preferential sources of water and organic delivery to the early Earth. Additional clues on the nature and magnitude of these accretionary processes are being obtained from the study of protoplanetary disks surrounding recently born solar-like stars.

SESSION 5: ORAL CONTRIBUTIONS

(by alphabetical order)

Kasuga, Toshihiro - Institute for Astronomy, University of Hawaii
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Title: Metal Abundances of Meteoroids in Meteor Showers: Solar Heating Effect on the Meteoroids

Abstract: Solar heating effect on meteoroids during orbital motion in interplanetary space is investigated by the spectroscopic observations of several meteor showers. The effect is considered to change the metal abundances especially for relatively volatile element such as Na, and to depend both on the (1) perihelion distance of the orbit and on the (2) exposed duration time. Metal abundances of Leonid meteors with perihelion distance ~ 1 AU, and Geminid meteor of orbits with small perihelion ~ 0.14 AU are compared. Solar heating effects among Leonid meteoroids are investigated by the metal abundances deduced from two dust trails formed in different epochs. As a result, it is not confirmed that existence of this effect within about 100 years difference of the exposure. On the other hand, the depleted abundance of the Na was detected on a Geminid meteor, which indicates the existence of the solar heating effect depending on the (1) perihelion distance of the orbit. Calculation of the temperature of meteoroids with several perihelion distance revealed the possibility of depletion of the relatively volatile species such as Na in meteoroids with small perihelion ($q < 0.1$ AU) due to the solar heating effect.

SESSION 5: POSTERS
(by alphabetical order)

P52

Doménech, José Cantó - Escola Politècnica Superior d'Alcoi (Universitat Politècnica de València)
Satorre Aznar, Miguel Ángel - Escola Politècnica Superior d'Alcoi (Universitat Politècnica de València)
Domingo Beltrán, Manuel - Escola Politècnica Superior d'Alcoi (Universitat Politècnica de València)
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Title: Study of ices at the laboratory

Abstract: Ices may exist in different astrophysical scenarios. For example in the dense interstellar medium (ISM) we can found them as a mantle over the surface of dust grains and also in our Solar System (SS) there are ices on different objects: planets, moons, asteroids, comets and meteorites. Ices in space are composed primarily of water and other simple compounds and they can be transformed by different processes. As a result of it new molecules could be formed. For this reason it is not a surprise the large amount of chemical species detected in the ISM and in the SS. At the laboratory it is possible to study these ices by depositing ice analogues of a particular astrophysical scenario and by ultraviolet photolysis with an UV lamp, we can also obtain new molecules. On the other hand it is known that meteorites contain abundant organic material that represents a sample of interstellar matter and some authors suggest that it have been formed in a multi-step process from the interstellar cloud by means of different ways before the solar system was formed. In this contribution we want to present the possibilities of our Astrolaboratory to study molecules founded in astrophysical environments.

Session 6:
METEOROID FLUX, IMPACT HAZARD, AND SOLAR SYSTEM DUST

SESSION 6: INVITED TALKS
(by alphabetical order)

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Title: Meteoroids, Meteors, and the NEO Impact Hazard

Abstract: The most destructive catastrophes that have shaped the evolution of life on Earth have been impacts of multi-km asteroids and comets. But they strike extremely rarely and the Spaceguard Survey has found most NEAs >1 km diameter. So attention is turning toward smaller bodies, which strike much more often. While their frequency is only ~1% that of other equally-damaging natural hazards, small NEOs can be discovered long before impact, permitting warning and evacuation, or even diversion/destruction of the NEO. So there could be a political mandate to stop such a preventable disaster. Among the issues involving the small end of the NEO size distribution are these: What is the lower limit on the size of a potentially destructive bolide? What is the physical structure of small NEOs (e.g. monolith versus rubble-pile)? How reliably known is the size distribution of meteoroids ranging from those that produce fireballs up to Tunguska-sized projectiles? Can bolides frighten people so that they take inappropriate action (retaliate for the "nuclear attack")? Can military satellilte fireball data be released to the public more rapidly and completely? How dangerous are meteorite falls?

Nuth III, Joseph A. - NASA Goddard Space Flight Center
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Title: What was the chemical composition of the planetesimals that formed the terrestrial planets?

Abstract: Is there an asteroid type or meteorite class that best exemplifies the materials that went into the terrestrial planets? Carbonaceous chondrites were once the objects of choice to make the Earth, and in the minds of many researchers this choice is still valid. However, the origin of chondritic meteorites is still unclear. At the extremes they could either be fragments of very small parent bodies that never became hot enough to undergo geochemical modification other than mild lithification, or they could be the remnant of the uppermost layers of a body that had undergone some significant degree of internal differentiation, while the top layers remained cool due to radiative heat loss or loss of volatiles to space. This latter case is problematic since the timescale for the evolution of such a small body could be longer than the timescale for the accretion of the Earth. In addition, large-scale circulation of materials in the primitive solar nebula could greatly increase the diversity of materials near 1 AU while also making the entire inner solar system both more homogeneous and much wetter than previously expected.

SESSION 6: ORAL CONTRIBUTIONS
(by alphabetical order)

Dikarev, Valeri - Max Planck Institute for Solar System Research
Preuss, Oliver - Max Planck Institute for Solar System Research
Solanki, Sami - Max Planck Institute for Solar System Research
Krueger, Harald - Max Planck Institute for Solar System Research
Krivov, Alexander - Astrophysical Institute of the Friedrich Schiller University
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Title: Understanding the WMAP Results: The Low-l Anomalies and Dust in the Vicinity of the Solar System

Abstract: Analyses of the cosmic microwave background (CMB) radiation maps produced by the Wilkinson Microwave Anysotropy Probe (WMAP) have revealed anomalies not predicted by the standard cosmological theories. It has been suggested that a dust cloud in the vicinity of the Solar system may be the cause for these anomalies. In this paper, the thermal microwave emission by dust particles at the wavelengths of several millimetres is investigated in
order to provide quantitative estimates of the contribution of the Solar system-bound dust to the CMB.

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Dikarev, V. - MPG MPS
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Title: Comparison of meteoroid flux models for near Earth space

Abstract: Over the last decade several new models for the sporadic interplanetary meteoroid flux have been developed. These include the Meteoroid Engineering Model (MEM), the Divine-Staubach model and the Interplanetary Meteoroid Engineering Model (IMEM). They typically cover mass ranges from 10-12 g (or lower) to 1 g and are applicable for model specific sun distance ranges between 0.2 A.U. and 10 A.U. Near 1 A.U. averaged fluxes (over direction and velocities) for all these models are tuned to the web established interplanetary model by Grün et. al. However, in many respects these models differ considerably. Examples are the velocity and directional distributions and the assumed meteoroid sources. In this paper flux predictions by the various models to Earth orbiting spacecraft are compared. Main differences are presented and analysed. The persisting differences even for near Earth space can be seen as surprising in view of the numerous ground based (optical, radar) and in-situ (captured IDPs, in-situ detectors and analysis of retrieved hardware) measurements and simulations. Remaining uncertainties and potential additional studies to overcome the existing model discrepancies are discussed.

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Cooke, William J. - NASA Marshall Space Flight Center/EV13
Swift, Wes - Raytheon/MSFC
Hollon, Nick - Jacobs/MSFC and Villanova University
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Title: NASA's Lunar Meteoroid Impact Monitoring Program

Abstract: NASA's Meteoroid Environment Office has implemented a program to monitor the Moon for meteoroid impacts from the Marshall Space Flight Center. Using off-the-shelf telescopes and video equipment, the Moon is monitored for as many as 10 nights per month, depending on weather. Custom software automatically detects flashes which are confirmed by a second telescope, photometrically calibrated using background stars, and published on a website for correlation with other observations. Hypervelocity impact tests at the Ames Vertical Gun Facility have been performed to determine the luminous efficiency and ejecta characteristics. The purpose of this research is to define the impact ejecta environment for use by lunar spacecraft designers of the Lunar Precursor Robotics Program and Constellation (manned lunar) Program. The observational techniques and preliminary results will be discussed.

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Sarugaku, Yuki - University of Tokyo
Kimata, Masafumi - Ritsumeikan University
Hong, SeungSoo - Seoul National University
Levasseur-Regourd, Anny-Chantal - Universite Paris VI
Mann, Ingrid - Kobe University
Mukai, Tadashi - Kobe University
Iwagami. Naomoto - University of Tokyo
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Satoh, Takehiko - Japan Aerospace Exploration Agency
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Title: Observations of Zodiacal Light during the cruising phase of PLANET-C/VCO Mission

Abstract: We present an observing project in the cruising phase of PLANET-C/VCO (Venus Climate Orbiter) mission. PLANET-C will give us a unique opportunity to observe the inter planetary dust from various viewing points in the solar system without any contaminations of sky light, and will map the spatial distribution of the zodiacal dust cloud along the heliocentric distance, the resonance structures, the local emissivity, and small clumps. IR2 and IR1 cameras onboard PLANET-C, whose main target is to monitor the Venusian atmosphere at near infrared wavelength, are designed very carefully to extend their sensitivities toward the faint zodiacal light, and to realize very

stable response. A PtSi infrared sensor is developed for dedicated use of the cameras, which has a large dynamical range covering bright Venusian surface down to the faint flux of the zodiacal light. Significant problem on the inter planetary dust cloud is the origin itself, since the lifetime of the interplanetary dust under the Poynting-Robertson drag is much shorter than the age of the solar system. PLANET-C capabilities such as good sensitivities for extended sources, unique viewing points, fine spatial resolutions will open a new horizon for these studies.

SESSION 6: POSTERS
(by alphabetical order)

P53

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Title: Mineralogy of HED meteorites using the Modified Gaussian Model

Abstract: The correlation between specific meteorites and asteroids is a long-standing problem. The best-known correlation seems to be the HED–Vesta, although several problems still remain to be solved. The identification of NWA 011 and other HED meteorites as NOT coming from a common pool open the door to the presence of another basaltic/differentiated parents bodies other than Vesta. We report the spectral reflectance analysis (0.4-2.5 microns) of a set of HED meteorites, taken from the RELAB database. We used the Modified Gaussian Model to fit the spectra to a series of overlapping, modified gaussian absorptions. The fitted individual bands are validated against established laboratory calibrations. With spectral resolution extending to the near-infrared, we are able to resolve the presence of both high-calcium pyroxene (HCP) and low-calcium pyroxene (LCP) and, thus, use the HCP/(HCP+LCP) ratios to remotely trace igneous processing on the parent asteroids. A search of this mineral provides a useful probe of differentiation. The high HCP/(HCP+LCP) ratios found require extensive differentiation of these asteroids and/or their primordial parent body. The degree of melting obtained for the eucrites, using the former ratio, is comparable with that obtained in laboratory.

P54

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Title: Measurement of Primary Ejecta From Normal Incident Hypervelocity Impact on Lunar Regolith Simulant

Abstract: The National Aeronautics and Space Administration (NASA) continues to make progress toward long-term lunar habitation. Critical to the design of a lunar habitat is an understanding of the lunar surface environment. A subject for further definition is the lunar primary ejecta environment. The document NASA SP-8013 was developed for the Apollo program and is the latest definition of the primary ejecta environment. There is concern that NASA SP-8013 may over-estimate the lunar primary ejecta environment. NASA's Meteoroid Environment Office (MEO) has initiated several tasks to improve the accuracy of our understanding of the lunar surface primary ejecta environment. This paper reports the results of experiments on projectile impact into pumice targets, simulating lunar regolith. The Ames Vertical Gun Range

(AVGR) was used to accelerate spherical Pyrex projectiles of 0.29g to velocities ranging between 2.5 km/s and 5.1 km/s. Impact on the pumice target occurred at normal incidence. The ejected particles were detected by thin aluminum foil targets placed around the pumice target in a 0.5 Torr vacuum. A simplistic technique to characterize the ejected particles was formulated. Improvements to this technique will be discussed for implementation in future tests.

ℙ55
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Title: Lunar Gravitational Focusing of Meteoroid Streams and Sporadic Sources

Abstract: Recent work on gravitational focusing of meteoroid streams and their threat to satellites and astronauts in the near-Earth environment has concentrated on Earth acting as the gravitational attractor, totally ignoring the Moon. Though the Moon is twelve-thousandths the mass of the Earth, it too can focus meteors, albeit at a much greater distance downstream from its orbital position in space. It will be shown that at the Earth-Moon distance during particular phases of the Moon, slower streams and sporadic sources can show marked meteoroid flux enhancements in Earth's immediate neighborhood. For meteoroid streams, when the right geometric alignment occurs, this arises as a pencil-like beam of particles only a few tens of kilometers wide with an effective high level of flux passing through the near-Earth environment. For sporadics, this arises as a monthly periodic enhancement on the order of a doubling of the background flux, whenever the Moon aligns with the Helion, Anti-Helion, and Apex sources.

ℙ56
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Title: An Observational Study of Mass Injection Rate from Short-Period Comets into Interplanetary Space

Abstract: The complex of interplanetary dust cloud is observable as the zodiacal light in the visible wavelength or zodiacal emission in the infrared wavelength. To maintain the zodiacal cloud against the erosion by the Poynting-Robertson drag and the mutual collision among particles, there should be the substantial dust sources in the present Solar System. We study the interplanetary dust particles of comet origin through the observations of cometary dust tail and dust trail. The obtained images are compared with the semi-analytical dust dynamical model. In this presentation, we discuss how much cometary particles inject into the interplanetary space.

P57

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Title: Searching for the parent of the Tunguska Cosmic Body

Abstract: The origin of the TCB is not known yet, therefore we continued our earlier work. This time we made a more extensive study of the TCB origin on dynamical grounds. We used three data sets: 3311 of the TCB orbits, 2656 of the NEA orbits and 582 of the cometary orbits. We believe that the TCB is a fragment resulting from the partial disruption of a NEA or a comet. To find such object, at least its plausible candidate, we applied approach based on the well known concept of the dynamical similarity --- we have compared the geocentric or heliocentric dynamical parameters of each NEOs with each of the TCB particles. Two steps were made: first, we repeated an idea of Kresak by comparing the geocentric coordinates of the TCB radiant with those of the NEOs. In the next search we made more extensive analysis. During a long term dynamical evolution of all NEOs and the TCB particles, we searched for similarities between their heliocentric obits. As a general result, amongst the TCB's and asteroidal orbits we observed much more similar cases and a different pattern of the high orbital similarity than in case of the comets.

P58

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Title: Impact Rates on Earth from the study of sporadic impact flashes on the Moon.

Abstract: In 2001 we started a systematic lunar impact flash survey that resulted in the first detection of sporadic impact flashes on the Moon (Ortiz et al., 2006). The survey allowed us to estimate the impact flux on Earth as a function of energy of the incoming meteoroid provided that a luminous efficiency parameter for the impact processes is used. Even if one uses an already optimistically high luminous efficiency, the impact rate on Earth of large meteoroids is at least three times higher than the currently accepted flux rate (Brown et al. 2002) and enhances the impact hazard considerably. The recent collision of the ESA Smart-1 spacecraft on the Moon has also allowed us to put additional constraints on the luminous efficiency and the resulting impact rates are indeed higher than the widely accepted values. We present other evidences that confirm our results. We investigated what the causes of the discrepancy can be and realized that the source of the different impact rates might be the fact that our technique is sensitive to the impacts of very volatile material, whereas the currently most accepted values of impact rates may only apply to material of asteroidal type.

ℙ59

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Title: Algorithms for Lunar Flash Video Search, Measurement, and Archiving

Abstract: Lunar meteoroid impact flashes provide a method to estimate the flux of the large meteoroid flux and thus their hazard to spacecraft. Although meteoroid impacts on the Moon have been detected using video methods for over a decade, the difficulty of manually searching hours of video for the rare, extremely brief impact flashes has discouraged the technique's systematic implementation. A prototype has been developed for the purpose of automatically searching Lunar video records for impact flashes, eliminating false detections, editing the returned possible flashes, and archiving and documenting the results. The theory and organization of the program is discussed with emphasis on the filtering out of several classes of false detections and retaining the brief portions of the raw video necessary for in depth analysis of the flashes detected. Several utilities for measurement, analysis, and location of the flashes on the moon included in the program are demonstrated. Application of the program to a year's worth of Lunar observations is discussed along with examples of impact flashes as well as several classes of false impact flashes.

ℙ60

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Title: Planetary Science Archive (PSA): Rosetta Archive Status

Abstract: The Planetary Science Archive (PSA) is an online database (accessible via http://www.rssd.esa.int/PSA) implemented by ESA/RSSD and utilising the Planetary Data System (PDS) standard. The PSA user is offered a broad range of search possibilities which can be combined without restrictions and are executed across the whole database. Currently the PSA contains science data from the Giotto (Halley), Mars Express, SMART-1 (Moon) and Huygens (Titan) missions, and the Rosetta Supplementary Archive (Wirtanen). The first science and engineering data collected by

the Rosetta orbiter instruments will be made available to the public in April 2007, following the Peer Review being held from December 2006 to February 2007. Rosetta was launched in March 2004 to rendezvous with comet 67P/Churyumov-Gerasimenko (C-G) in May 2014. After having placed a lander on the comet's surface, the Rosetta orbiter will continue to orbit C-G and accompany the comet through perihelion. Rosetta makes use of three Earth swingbys and one Mars swingby to reach C-G. Rosetta will also perform close flybys at two asteroids, namely 2867 Steins and 21 Lutetia. In addition, Rosetta makes scientific observations of targets of opportunity, e.g. the encounter of the Deep Impact probe with comet 9P/Tempel 1.

ALFABETICAL INDEX
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