Abstracts

Martin Baláž Saturday 11:25–11:40

Investigation of meteor properties using a numerical simulation

Martin Baláž, Juraj Tóth

We present new capabilities of the meteor simulation toolkit ASMODEUS. We used the numerical simulation to visualize how varying the initial properties of meteoroid particles affects the properties of corresponding meteors and the probability of detection by a ground-based observer. Unlike in simulations of meteor showers, where properties of meteoroids are sampled from predefined distributions and meteor datasets are evaluated statistically, in this method meteoroid properties are varied systematically. Most parameters remain constant, while one or more attributes (such as initial particle mass, entry angle or material properties) are assigned evenly spaced values from defined intervals, either on a linear or logarithmic scale.

Possible applications of the method include investigation of beginning and terminal heights, luminosity profiles, effects of diurnal or annual variation of upper atmospheric density and many more. Comparison of the output of the simulation to observational data for single meteors also makes validation of theoretical models feasible, and enables us to develop better ablation and deceleration models.

Dušan Bettonvil Poster

Python Ablation and Dark Flight Calculator

The last two years I participated in various meteorite search campaigns. None of them were successful in finding the meteorite. This gave me the idea to create a Python program to calculate the dark flight of meteors.

Felix Bettonvil Sunday 09:00–09:15

Daytime Fireball capturing

Traditionally, fireball patrol cameras are constructed to capture fireballs during night time. That's great, but fireballs –and in particular meteorite dropping ones– do not only appear at night time: there are various examples of great fireballs that did appear at twilight or even daytime. In an attempt to have also daytime coverage I will present some recent test work on a panoramic security cam.

Uroš Bettonvil Poster

My first visual observation

I describe how I did my very first visual IMO observation session.

Stijn Calders Friday 10:55–11:10

The Radio Meteor Zoo: identifying meteor echoes using artificial intelligence

Stijn Calders (BIRA-IASB), Stan Draulans (Universiteit Antwerpen), Toon Calders (Universiteit Antwerpen), Hervé Lamy (BIRA-IASB)

BRAMS (Belgian RAdio Meteor Stations) is a Belgian network using forward scatter radio techniques to detect and study meteoroids entering the Earth's atmosphere. It consists of one beacon and 26 identical receiving stations, and it generates a huge amount of data with thousands of meteor echoes detected every day. With such large amounts of data, it is impossible to process it all ourselves.

The automatic detection of meteor echoes in the BRAMS data has proven to be a difficult problem to solve. Therefore the BRAMS researchers, in collaboration with Zooniverse team, have launched a citizen science project called the Radio Meteor Zoo (RMZ) in August 2016.

Since the beginning of the RMZ, more than 8500 volunteers have identified thousands of meteors. Using this data set, a new way to set up an automatic detection algorithm is being explored: a convolutional neural network (CNN, a special class of deep neural networks designed to analyze images) has been trained to identify meteors in new spectrograms. During this talk we will present the CNN model and discuss how its performance is evaluated. We will also discuss how to improve this algorithm in the future.

David Čapek Friday 13:30–13:40

Mass determination of iron meteoroids

David Čapek, Pavel Koten, Jiří Borovička, Vlastimil Vojáček, Pavel Spurný, Rostislav Štork

The initial mass of a meteoroid can be estimated from the video observations by two usual ways. If the meteor shows deceleration, the dynamical mass can be determined. The light curve together with knowledge of luminous efficiency allows determining the photometric mass. In the case of small iron meteoroids there is one more way. The beginning height corresponds to reaching the fusion temperature on the meteoroid's surface. These bodies are almost isothermal due to high heat conductivity of the iron and the beginning height simply depends on zenith angle of radiant, initial velocity, and initial mass. This method is however limited to smaller meteoroid sizes. We will show the results from analytic theory, numerical modelling and the use on observed data.

François Colas Friday 09:55–10:10

FRIPON first results after 3 years of observations

François Colas, Brigitte Zanda, Simon Jeanne, Mirel Birlan, S. Bouley, P. Vernazza, J.L. Rault and J. Gattacceca

We will present the first results of the FRIPON network after 3 years of observations. We will focus our presentation on the more than 2000 orbits obtained.

François Colas Saturday 10:50–11:05

FRIPON Network internal structure

Adrien Malgoyre (Pytheas, Marseille), François Colas (IMCCE, Observatoire de Paris)

We will present an overview of our internal scripts and softwares used in the Fripon network after a few years of improvement. As a pooled IT Service and because we are engaged in other science projects, our goal was to increase the level of automation for this long time survey. Now it's almost done! Through a few simplified diagrams, we will present the data recovery chain as well as the associated open-source software that allows us to magnify this network of observation easily. The goal of the presentation is to show how FRIPON works and how it can be extended over Europe.

Peter Dolinsky Poster

Comparison of radio meteor observations during the period from 1. to 17. August 2019

Peter Dolinsky, Ales Necas, Jan Karlovsky

During the period from 1. to 17. August 2019 we performed radio meteor observations from 3 different stations (Iza, Hurbanovo, Vrbove). The main aim was to compare detecting systems and differences between them in terms of sensitivity and interferences. The period around the maximum of the Perseids was chosen to obtain higher detected hourly rates of echoes. The main study was done at frequency 143.05 MHz, but 50 MHz apparatus was used too. Correlation coefficient and linear dependences between detected rates were determined. These values were from R=0.7 to R=0.9 in different data sets. Also 143 MHz and 50 MHz rates were compared. We also estimated the maximum of the Perseids using 25-hour moving averages to circa 13,5 August 2019 UT. During the period from 12. to 13. August we used the data from a 4th station in Hlohovec to compare radio spectrums of strong echoes from these stations.

Martin Ferus Friday 13:55–14:10

Simulation of meteors by TW-class high power laser - advantages, limits and future challenges

Meteor spectra are usually interpreted using data from databases and tables. Several studies already demonstrated very sophisticated calculations of meteoroid body elemental compositions based on the computation of synthetic meteor spectra or spectral analysis of airglow plasma containing evaporated, atomized and ionized meteoroid matter. However, considering accuracy, reliability of computations, lack of laboratory experimental data in this field as well as complicated physical structure of meteor plasma, such qualitative assignment or quantitative calculations are still extensively discussed in the scientific community. Even on the laboratory level, many studies have already shown the high complexity of the acquisition and the interpretation of the data recorded by techniques of emission spectroscopy in fashion and philosophy similar to spectral analysis of meteor plasma, i.e., detection and quantification of the elements ablated from complicated multicomponent matrices. The current study is focused on the

application of terawatt-class laser induced breakdown spectroscopy (TC-LIBS) of real samples of chondritic meteorites. High resolution and high precision emission spectra containing spectral lines typical for real meteoric spectra were recorded. Experimental data were compiled in the form convenient for the meteoric spectra interpretation and calibration. TC-LIBS has been carried out by the high-power terawatt-class laser facility, the Prague Asterix Laser System (PALS) and also multiple laser sources for comparison. The spectra have been simultaneously recorded by an Echelle high-resolution spectrograph in the UV/VIS spectral ranges and by a spectrograph used for real observation of meteor spectra. We also present synthetic spectra calculated based on data from the NIST atomic spectra database. We assembled etalon qualitative tables of major meteoric spectral features which can be used both for the spectral wavelength calibration of low-resolution observational instruments and for exact interpretation of meteor spectra. The data are compared with the real meteor spectra.

Bernd Gährken Sunday 10:50–11:15

Polarization of the night sky in Chile 2019

Chile has some of the best astronomical locations on earth. In 2019 there was a solar eclipse in Chile which attracted many observers. As solar eclipses always fall on new moon, so there was an opportunity to enjoy the dark sky. The nights were used to make some pictures with a polarization-filter to study the glow of the night sky.

Pete Gural Poster

Deep Learning Applied to Post-Detection Meteor Classification

Advanced machine learning techniques have been applied to automating the confirmation and classification of potential meteor tracks in CAMS video imagery. Deep learning performs remarkably well, surpassing human performance, and will likely supplant the need for human visual inspection and review of collected meteor imagery. Recurrent neural networks (RNNs) and convolutional neural networks (CNNs) have been applied to both meteor time series measurements and video meteor imagery respectively. The CNN MeteorNet will be explored in the future as a potential upstream meteor detector.

Mária Hajduková Friday 16:35–16:50

Parent bodies of some minor meteor showers

Mária Hajduková and Luboš Neslušan

We found new parent bodies of several minor meteor showers using the procedure of modeling theoretical streams of chosen periodic comets. Studying their dynamical evolution for a suitably long period can reveal alterations of the initial orbital corridor in which is commonly situated the orbit of the parent body. Alternative corridors of orbits are formed as a result of the influence of the gravitational perturbations of big planets and non-gravitational forces. If more than a single corridor of a given stream passes through the Earth's orbit, we observe several meteor showers associated with the same parent body.

Moreover, the procedure used allows us to predict new meteor showers associated with the examined parent body, or exclude its relationships to any other meteor showers.

Our model of the C/1964 N1 stream implied the existence of four distinct filaments that approach

Earth's orbit. Consequently, we searched for corresponding showers in the meteor databases. The comet is the parent body of the established shower #533 July Xi Arietids, of #023 Epsilon Geminids, and maybe of #718 Xi Geminids, although this relationship is rather uncertain. A real counterpart of the fourth filament was not found in the databases.

Comet C/1975 T2 (Suzuki-Saigusa-Mori) is the parent body of a single shower, #524 Lambda Ursae Majorids.

Comet C/1979 Y1 (Bradfield) is the parent body of the established shower #175 July Pegasids and a questionable shower, represented only by 2 meteors at the moment, #104 Gamma Bootids. Another predicted shower was also found among real meteors but it is not listed in the IAU MDC list. We named this new shower Alpha Microscopiids.

Comet C/1963 A1 (Ikeya) is, according to our simulations, the parent body of five meteor showers. Three of the predicted showers were identified with #101 Pi Hydrids, #729 Delta Corvids and, less certainly, with #483 November Alpha Sextantids. The fourth prediction is a new meteor shower, which we named as Theta Leonids. The last shower was predicted as low in numbers, and, hence, no real counterpart was found in the databases.

Mike Hankey Friday 09:35–09:55

The All Sky 6 and Video Meteor Program of the AMS Ltd.

Mike Hankey, Vincent Perlerin and David Meisel
(The American Meteor Society, Ltd.
Geneseo, NY USA)

Over a period of several years, the American Meteor Society, Ltd. has developed a custom hardware and software system for capturing, reducing, solving and permanently storing meteor event data along with all-important corroborating video media from which high accuracy and reliable information can be gleaned. The connected hardware and software developed for trajectory analysis up to this point has utilized mainly open source materials and steadily matured into a modern, online system with wide international connections through 'live' internet interactions between the various camera stations. Some critical software components and algorithms used by our system for the astrometric calibration of the cameras as well as trajectory and orbit solving have been developed by Denis Vida and provided through his RMS (Raspberry Pi Meteor Station) and WMPL (Western Meteor Python Library) open-source projects. These routines and solvers are currently integrated into the AMS routine workflow along with some others from the open or published literature.

Mike Hankey Poster

The All Sky 6 and Video Meteor Program of the AMS Ltd.

Mike Hankey, Vincent Perlerin and David Meisel
(The American Meteor Society, Ltd.
Geneseo, NY USA)

This is an accompanying poster to the talk of the same title.

Anna Kartashova Friday 13:40–13:55

The study of meteoroid parameters with multi-techniques data

Anna Kartashova[1], Yury Rybnov[2], Olga Popova[2], Dmitry Glazachev[2], Galina Bolgova[1], Vladimir Efremov[2]
[1] Institute of Astronomy of the Russian Academy of Sciences, Moscow, Russia
[2] Institute of Dynamics of Geospheres Russian Academy of Sciences, Moscow, Russia

Meteoroids are the source of information about the origins of our Solar System. They are one of the most difficult objects to observe in the Solar system (we do not know in advance either the area on the celestial sphere, or the time when the event occurs. Besides, a meteor flash in the atmosphere has duration few seconds or less.). The interaction of meteor particles with the atmosphere produces the optical (actually meteors) and infrasound emissions. The meteor properties (mass, size, density, etc.) are estimated based on the various observational data under different assumptions. The details of meteor-atmosphere interaction are poorly known, the parameters of meteor particles are determined with large uncertainty. Simultaneous registration of meteors by different techniques provides the possibility to refine both the meteor parameters and models of particle interactions with the atmosphere. The goal of simultaneous observations is to decrease uncertainty in the meteoroid masses and study the formation and propagation of pressure pulses which are formed due to the interaction of meteoroids with the atmosphere.

The multi-technique (optical and acoustical) observations are carried out in the Institute of Astronomy RAS and Institute of Dynamics of Geospheres RAS from 2016 to the present time. The optical observations are carried out at three stations: Zvenigorod observatory of the Institute of Astronomy RAS (ZO INASAN), Geophysical observatory Mikhnevo of the Institute of Dynamics of Geospheres RAS (GPhO Mikhnevo) and 'Istra' station. Simultaneously with the optical observations the pressure variations are recorded at the ZO INASAN, GPhO Mikhnevo and IDG RAS in Moscow.

Ákos Kereszturi Friday 17:00–17:10

Where are the missing fireballs?

Ákos Kereszturi, Vilmos Steinmann

The formation of small impact craters on the Moon should show an equivalent rate as the occurrence of the corresponding sized fireballs in the Earth's atmosphere. Using physical equations the crater sizes and corresponding blast energies could be identified. For example 0.15-0.32 m diameter exploded meteoroids would have produced 3.0-6.5 m sized craters on the Moon. The areal density of such craters was found to be around 1.08E-5/km^2 on the lunar surface that corresponds to 80-140 Ma age. Based on the occurrence of observed Earth atmospheric blasts, only 0.58 craters during 80 Ma period (at 0,24 km^2) or 1.61 craters during 140 Ma period would have been formed on the Moon. The observed fireball rate is 0.03-0.06% of the corresponding areal crater density, indicating that far more craters formed on the Moon than expected based on fireballs observed in the Earth's atmosphere. The difference is probably related to observational selection effects, which is worth considering to see how many potentially observable fireballs are expected, including daytime events.

This work was supported by the GINOP-2.3.2-15-2016-00003 project.

Maximilian Klaß Friday 17:10–17:25

Impact fluxes on the Columbus module of the ISS: survey and predictions

Gerhard Drolshagen, Maximilian Klaß, Robin Putzar, Detlef Koschny, Björn Poppe

Launched in 2008 the Columbus module of the International Space Station (ISS) has by now been exposed for more than 10 years to fluxes from meteoroids and space debris particles. Numerous impact craters are present on its outer surfaces.

A group of researchers from various German entities has initiated an impact survey of outer surfaces of the Columbus module. Such a survey was supported by ESA and NASA and finally carried out in September 2018 by a video camera on the Canadian robot arm. Impact features bigger than a few hundred microns are visible. With its large size of several tens of square meters and its long exposure duration the surfaces of the ISS modules provide a unique opportunity to record fluxes of particles in space before they enter the atmosphere.

A systematic analysis of the impact craters is ongoing. This is done in several steps: combining the different video sequences, identifying impact craters, measuring them and converting measured crater sizes to particle diameters. The results will be compared to predictions from existing meteoroid and space debris flux models and, if required, will lead to improved flux and population models.

In this paper examples of impact craters on the ISS will be shown and impact flux predictions will be presented.

Detlef Koschny Sunday 11:15–11:35

The ESA Leonids 2002 Expedition

Koschny, D., Trautner, R., Zender, J., Knöfel, A., Diaz del Rio, J., Jehn, R.

In the year 2002, ESA undertook an observing campaign to Southern Spain to observe the expected Leonid storm under good weather conditions. Two teams were set up, one close to the observatory of the Astronomical Institute of Granada, the other one in La Sagra, about 150 km away from the first location. Our observations encompassed measurements with optical video cameras with image intensifiers, and a ELF/ULF measurement system based on an experiment flown on the Cassini/Huygens mission.

During an observing period of 3 nights, we could perform successful observations. Visual meteor counts contributed to the world-wide Zenithal Hourly Rate measurements collected by the International Meteor Organization.

In this presentation, we introduce the instrumentation and recording equipment. The type and amount of available data is presented, and the scientific results are shown. We also give a short summary of the results from a video camera that was flown onboard a DC-8 airplane in a campaign organized by the SETI institute.

This presentation is a historical repeat of a presentation given one year after the campaign at the same location.

Pavel Koten Friday 16:05–16:20

Meteor pairs among Geminids

Pavel Koten, David Čapek

Visual and telescopic observers repeatedly reported that meteors appear in pairs or even groups. A search for meteor pairs in the Ondřejov video archive shows that it contains at least 500 cases of the meteors which were recorded with a gap of 1 second. In this talk we will concentrate on the Geminid meteor shower. The analyses of the closest pairs will be presented.

Anna Křivková, Lukáš Petera, Martin Ferus Poster

Application of High Power Lasers for a Laboratory Simulation of Meteor Plasma

Interpretation of meteor plasma dynamics, its spectra and the dominant spectral features is currently mostly provided by mathematical modelling. Our results show that synthetic spectra calculation is not the only method for such in-depth study of meteor spectra. Laboratory experiments can help with qualitative and quantitative evaluation of the observational data and assignment of important spectral features in meteor emission spectra. Plasma induced by high power lasers provides a very suitable experimental approach for such purely laboratory simulation of meteor plasma. Importantly, target experiments with ablation of various real specimens of meteorites help to understand behavior of meteor plasma under strictly controlled laboratory conditions. We show that at least extrapolation of parameters is better than only theoretical simulation. In our study, we provide description, evaluation of advantages and also limitations of this new experimental approach based on laser ablation of real meteorite samples using a wide range of laser sources: Terawatt-class large laser infrastructure PALS, high power Ti:Sa femtosecond laser, laboratory Nd:YAG, ArF excimer laser and large diode pumped solid state laser infrastructure HiLASE.

Hervé Lamy Friday 11:10–11:30

Calibration of the BRAMS interferometer

H. Lamy[1], M. Anciaux[1], S. Ranvier[1], A. Martínez Picar[2], S. Calders[1], A. Calegaro[1], C. Verbeeck[2]
[1] Royal Belgian Institute for Space Aeronomy
[2] Royal Observatory of Belgium

BRAMS is a Belgian network using forward scatter radio techniques to detect and study meteoroids entering the Earth's atmosphere. One of the 26 receiving stations is located in Humain and is a radio interferometer using phase difference measurements between five antennas to accurately retrieve the direction of arrival of a meteor echo.

The direction of arrival of a meteor echo is not known a priori and so the meteor echoes cannot be

used to calibrate the interferometer, i.e. to check that the retrieved direction of arrival is consistent with the position of the source. During this talk, three methods to calibrate the interferometer are presented using 3 sources at known positions:

1) data from a drone equipped with a transmitter and flying in the far-field of the interferometer

2) data from trajectories obtained from CAMS-Benelux optical observations for which the direction of the first Fresnel zone can be calculated

3) data from airplanes whose positions were recorded using ADS-B signals.

Advantages and limitations of each method will be highlighted.

Vladislav Lukashenko Poster

Numerical model of flight and scattering of meteor body fragments in the Earth's atmosphere

Lukashenko V., Maksimov F.

A method is presented that allows to simulate a supersonic flight of several meteor body fragments in the Earth's atmosphere. At first the aerodynamic problem is solved by calculation of the flow around meteor body fragments, then the ballistic problem is solved by moving bodies according to the acting aerodynamic forces and their own velocities within a short period of time, and the process is repeated. The method was tested on the problem of fragmentation of a meteor body into two identical circular cylinders that have been placed near each other on the line perpendicular to the flight direction. Obtained values for the velocities of the bodies are consistent with theoretical estimates.

Anastasios Margonis Sunday 09:45–09:55

Service Level Agreement (SLA) for European Network Fireball Data Provision

Anastasios Margonis, Stephan Elgner, Dieter Heinlein, Detlef Koschny, Regina Rudawska, Laura Faggioli, Jürgen Oberst

The European Fireball Network (EN) has been continuously operating since the late 60's, recording on average 30-40 fireballs every year. The overall objective of this work is to provide the data on these events recorded by the first generation camera stations of the EN to the European Space Agency (ESA) on a regularly basis. The collected metadata of all fireball events will be updated to meet the required import format and will be ingested into the Fireball Information System (FIS), maintained by ESA. This also includes the delivery of image data. Furthermore, fast reporting on fireball events from the existing digital all-sky camera at DLR in Berlin-Adlershof is in progress. At least one additional automated camera system is planned to be installed in the vicinity of the first camera station for simultaneous observations of events, allowing the reduction of double-station fireball image data. Information about recorded and confirmed fireball events will be sent to ESA via e-mail in the predefined format.

Anastasios Margonis Poster

Nachtlicht-BüHNE: a citizen science project for the development of an mobile app for night light phenomena

Marius Hauenschild, Anastasios Margonis, Stephan Elgner, Joachim Flohrer, Jürgen Oberst, Friederike Klan, Christopher Kyba, Helga Kuechly

The Nachtlicht-BüHNE project addresses citizen science in the context of scientific applications in astronomy, space research and light pollution. The goal is the development of an app-based citizen science projects in which citizens work together with scientists from the mentioned scientific communities. As part of two pilot studies on light pollution (GFZ/UFZ) and meteor science (DLR-DW/DLR-PF), scientists and citizens will initially develop two promiment examples of citizen science projects. Various collaborative techniques will be (further) developed, tested and evaluated. The resulting co-design methodology will be made available on a web platform with suitable tools for collaborative teamwork. The resulting web portal is intended to serve as an entry point and platform for the development of future, thematically related citizen projects within the Helmholtz Association. The bundling of topic-related projects in one portal promises to increase the visibility of Citizen Science activities of the HGF around the topic 'Night Light Phenomena'. In addition, possible synergy potentials result from the participation of interested citizens in several content-related projects.

Julia Marin-Yaseli de la Parra Friday 16:20–16:35

Analysis of a boulder in the surroundings of 67P

J. Marin-Yaseli de la Parra[1], M. Kueppers[1] and the OSIRIS-Team[2]
[1] ESA European Space Astronomy Centre (ESAC)
[2] Max Planck Institute for Solar System Research

Comet 67P/C-G is a dusty object. As it neared its closest approach to the Sun in late July and August 2015, instruments on Rosetta recorded a huge amount of dust enshrouding the comet.

This is tied to the comet's proximity to our parent star, its heat causing the comet's nucleus to release gases into space, lifting the dust along. Spectacular jets were also observed, blasting more dust away from the comet. This disturbed, ejected material forms the 'coma', the gaseous envelope encasing the comet's nucleus, and can create a beautiful and distinctive tail.

A single image from Rosetta's OSIRIS instrument can contain hundreds of dust particles and grains surrounding the 4 km-wide comet nucleus. Sometimes, even larger chunks of material left the surface of 67P/C-G.

A sizeable chunk was spotted a few months ago by astrophotographer Jacint Roger from Spain, who mined the Rosetta archive, processed some of the data, and posted the finished images on Twitter as an animated GIF. He spotted the orbiting object in a sequence of images taken by Rosetta's OSIRIS narrow-angle camera on 21 October 2015. At that time, the spacecraft was at over 400 km away from 67P/C-G's centre.

Julia Marin-Yaseli de la Parra Poster

Automated determination of dust particles trajectories in the coma of comet 67P

J. Marin-Yaseli de la Parra[1], M. Kueppers[1] and the OSIRIS-Team[2]
[1] ESA European Space Astronomy Centre (ESAC)
[2] Max Planck Institute for Solar System Research

We present the preliminary results and methods for an automated determination system of dust particles positions and trajectories in the near coma of comet 67P.

Antonio Martínez Picar Friday 11:30–11:45

The BRAMS receiving station v2.0

M. Anciaux[1], H. Lamy[1], A. Martínez Picar[2], S. Ranvier[1], S. Calders[1], A. Calegaro[1], C. Verbeeck[2]
[1] Royal Belgian Institute for Space Aeronomy
[2] Royal Observatory of Belgium

BRAMS is a Belgian network using forward scatter radio techniques to detect and study meteoroids entering the Earth's atmosphere. It consists of 26 identical receiving stations installed all over Belgium and one dedicated transmitter located in the south of Belgium. These receiving stations use analog ICOM-R75 commercial receivers, external sound cards as sampling device, and Spectrum Lab to acquire the data.

Since the ICOM-R75 receivers are not produced anymore and have suffered from failures due to aging at many different sites, the BRAMS team has decided to develop a new receiving station using digital RSP2 receivers, Raspberry Pi, and in-house developed software.

During this talk, the new system will be presented and the performances will be compared to the former one.

Sirko Molau Friday 09:15–09:35

FRIPON vs. AllSky6 : A Practical Comparison

In recent years, not only the number of video cameras and networks has grown world-wide in general, but there have been also a number of new projects to establish large video networks for fireball observation using standardized camera equipment. One if not the largest is the FRIPON network in central Europe, which consists of over 150 FRIPON cameras. Each CMOS camera is equipped with a fish-eye lens that covers a field of view of larger than 180 degree in diameter. Recently another fireball camera type dubbed AllSky6 has been presented, which follows a different approach. It consist of six individual CMOS cameras with 80x40 degree field of view, each, which together cover almost the full sky.

I have been operating a FRIPON and an AllSky6 camera at my observing site in Ketzür (5 km from the IMC venue) since November 2018. In this talk I want to share my experience with these cameras. I will not only compare technical parameters, but also practical aspects like software, data access, monitoring capabilities, costs and support for each of these cameras. The talk includes examples of fireballs which were recorded by both systems side-by-side.

Sirko Molau Friday 14:25–14:45

MeteorFlux reloaded

In 2011, Geert Barentsen introduced MeteorFlux – a web application to generate flux density graphs from video data of the IMO Video Meteor Network. It has been extensively used for almost every meteor shower analysis of IMO network data ever since. The tool received some improvements in 2013 and had been migrated to a new hardware platform in 2018, but despite a number of useful feature requests it was never really extended. Earlier this year, the tool finally received a number of functional upgrades, which will be discussed in this talk.

Sirko Molau Sunday 09:15–09:30

The daylight fireball of September 12, 2019

Jörg Strunk, Mike Hankey, Sirko Molau, Wolfgang Hamburg, Andre Knöfel

We will provide latest information about the daylight fireball of September 12, 2019, which occurred over northern Germany and was recorded among others by AllSky6 camera AMS21.

Theresa Ott, Esther Drolshagen Friday 09:00–09:15

NEMO Vol 3. – Status of the NEar real-time MOnitoring system

T. Ott, E. Drolshagen, D. Koschny, G. Drolshagen, C. Pilger, P. Mialle, J. Vaubaillon, and B. Poppe

NEMO, our NEar real-time MOnitoring system for bright fireballs, has been under development for about two years now. We have added and incorporated an increasing number of different data sources to the system. By combination, further information could already be obtained with the system which might otherwise have been lost.

An example is the size determination of the impacting NEO (near-Earth object) that caused a fireball. The size is of particular interest to us and can be found by combination of data sources from seemingly unrelated fields. We are systematically checking infrasound data of the IMS (International Monitoring System) operated by the CTBTO (Comprehensive Nuclear-Test-Ban Treaty Organisation). The network monitors the whole Earth during day and night in search for nuclear explosions. However, the technique is also applicable to bolides. If an event is detected via this method, the total deposited energy in the atmosphere can be determined from the data. In addition to the energy we can use the data in NASA's (National Aeronautics and Space Administration) CNEOS (Center for near-Earth object Studies) JPL (Jet Propulsion Laboratory) fireball database that contain information on the velocity. Connecting both pieces of information leads to a size and mass estimation.

On a more local scale, the established collaboration with the FRIPON (Fireball Recovery and Inter-Planetary Observation Network) system is a fast source of scientific information for objects that entered the Earth atmosphere above Europe which can be compared to other sources.

The alarm system will be further improved but already ensures that we are informed within a few hours about almost all fireballs that attract public attention in the western hemisphere. The system will be moved in the next months to ESA's Near-Earth Object Coordination Centre (NEOCC) to be

operated from there. The NEMO events will be included in the NEOCC's Fireball Information System (FIS). All collected data from public sources will be made available online. For especially interesting fireballs IMO (International Meteor Organisation) summaries are written on a more regular basis and hence the information and results derived from NEMO are already distributed.

In this presentation we will give an overview about the current status of NEMO and the next planned steps.

Dušan Pavlović Friday 15:25–15:35

School of Meteor Astronomy at Petnica Science Center

Dušan Pavlović, Vladimir Lukić

From 2009, Petnica Science Center and Petnica Meteor Group organized a specific program for high school students every year, to teach them basics of meteor astronomy. The program is designed for students to learn about the basic problems of meteor science, basic observational techniques and the broader context of meteor science (from planetary sciences perspective to meteoritics). Along with the lectures and demonstrations, the school is equally focused on the projects on which students are working during the school (and after it), from which some expanded even to the level of IMC contributions in the past years. The main idea is to educate youngsters about the meteor science and give them a framework to recognize and interpret the problems which meteor science had in the past, and the modern problems which are accessible to them, and to develop the reasoning needed to solve them. Also, the School of Meteor Astronomy is the introductory program for most of the Petnica Meteor Group visual observers. We will present the basic structure, ideas and methods of our educational system in the hope that this can become a model or an inspiration for other meteor groups and institutions, because we had a strong opinion that education of this kind is necessary for the amateur meteor community to develop.

Lukáš Petera Poster

Elemental Composition, Mineralogy and Orbital Parameters of the Porangaba Meteorite

Lukáš Petera, Libor Lenža, Jakub Koukal, Jakub Haloda, Bára Drtinová, Dalibor Matýsek, Martin Ferus and Svatopluk Civiš

The main goal of this study was to provide data on the bulk elemental composition, mineralogy and possible origin of the fresh Porangaba meteorite, whose fall was observed approximately at 17:35 UT on January 9. 2015, in many areas of the state of São Paulo in Brazil. There are only about 30 meteorites with known major parameters, namely their elemental composition, mineralogy, petrology combined with knowledge of their trajectory in the Solar system. In this study, we provide a next case of such a body described in particular detail: the famous Porangaba meteorite. The surface of the meteorite was mapped by Scanning Electron Microscopy (SEM) and optical microscopy. The mineralogy and the bulk elemental compositions of the meteorite were studied using Energy-Dispersive and Wavelength-Dispersive X-ray Spectroscopy (EDS/WDS) together with Electron Back Scatter Diffraction (EBSD). The bulk elemental composition was also studied (for comparison) by several other techniques, namely Atomic Absorption Spectrometry (AAS), Inductively Coupled Plasma Mass Spectrometry (ICP-MS), Laser Ablation ICP MS (LA ICP-MS) and Calibration-Free Laser-Induced Breakdown Spectroscopy (CF-LIBS). Based on the very poor visual camera records of the Porangaba meteorite fall and using UFOOrbit software (Sono-

taCo, 2009), its orbit were tentatively calculated and possible candidates of source bodies in the Solar system was tentatively proposed. We also provide a laboratory simulation of meteor spectra emissions that can be used for at least qualitatively comparing spectra from sporadic meteors with composition similar to Porangaba-like (L4 Ordinary Chondrite) bodies recorded by high-speed video-cameras equipped with simple grating spectrographs.

Jona Petri Saturday 11:05–11:25

Optimizing the scientific output of satellite formation for a stereoscopic meteor observation

Jona Petri (Institute of Space Systems, Stuttgart, Germany), Julia Zink, Sabine Klinkner

The Institute of Space Systems (IRS) and Technische Universität Berlin are planning a joint mission to observe meteors and dust particles using two small satellites of approximately 30 kg each in low earth orbit. The satellite bus is based on the TUBiX20 platform developed by Technische Universität Berlin while the IRS provides the payload and the data downlink system. The payload comprises a miniature dust sensor and a camera system for meteor observation. The mission consists of two identical satellites flying in formation for the stereoscopic observation of meteors, eventually allowing the calculation of the corresponding meteoroid trajectory. The constellation of the satellite formation, i.e. inter-satellite distance, orientation, orbit, etc., fundamentally influences the potential output of a meteor event observation. This paper focuses on the observation concept with the already selected camera system. Furthermore, requirements for the satellite system were derived. This is done by using several simulations written in Python as well as evaluating data from a ground based meteor observation system.

As described in an earlier paper, the camera is selected using a simulation as well. The chosen camera is able to observe meteors up to magnitude 3.4, depending on the meteor speed and angle. This value is necessary to run the second decisive simulation for meteor observation, namely the number of meteors observable per time unit.

However, this number does not only depend on the camera, but also on the chosen lens, the satellite orientation and distance and the orbit altitude. The simulation SWARMS (Simulator for Wide Area Recording of Meteors from Space) developed by Alexis Bouquet et al. was modified and extended to simulate the effects of the mentioned parameters on the number of observed meteors. The tool chain we developed around the simulation allows us to predict the number of observed meteors during the mission and thus to compare different configurations. Additionally, the effect of the satellite attitude control accuracy on the area observed and thus the number of meteors was simulated, which defines requirements for the satellite bus. Furthermore, a rough prediction of the number of observable meteors per time unit is calculated using different meteor distribution models.

Finally, the accuracy of the determined meteor trajectory depends also on the satellite's attitude knowledge accuracy. This is due to the way the trajectory is calculated. It is planned to use the software MOTS (Meteor Orbit and Trajectory Software, developed by Koschny and Diaz), which relies on an accurate meteor position measurement. This position is derived from the satellite attitude. In order to obtain requirements for the satellite attitude accuracy, de-biased meteor trajectory data from CILBO (Canary Island Long-Baseline Observatory) was analysed. The influence of the meteor position accuracy on the trajectory accuracy was analysed and requirements for the satellite were derived. The satellite attitude accuracy has a huge influence on the trajectory, therefore the satellite must determine its attitude as accurately as possible.

All in all the tool chain and data evaluation allows us to plan the mission accordingly and increase the scientific output.

Roman Piffl Friday 16:50–17:00

How many 'sporadics' are sporadic meteors?

A brief look at freely accessible meteor databases.

Jean-Louis Rault Saturday 10:35–10:50

A little tour across the wonderful realm of meteor radiometry

Jean-Louis Rault (International Meteor Organization)

Video cameras are very useful tools for observing meteors and for determining their trajectory parameters. However, the low-cost cameras generally used by the observation networks offer low acquisition speeds (a few dozen frames per second only) and their dynamic range is often limited (usually 12 bits).

In order to study in a detailed way the interactions of meteors with the atmosphere (ablation and fragmentation processes, behavior of plasma surrounding the bolides, etc.), it is therefore interesting to record accurate meteor light curves, measured at high speed and with a large dynamic range.

A design of meteor radiometer is described in this presentation. Based on simulations and preliminary field tests the defects and qualities of this radiometric sensor are highlighted.

Jürgen Rendtel Friday 15:05–15:25

Minor meteor shower anomalies: predictions and observations

Predictions of possible meteor shower activity based on meteoroid stream modelling are regularly provided with the Meteor Shower Calendar. Here we check a few of the predictions using visual and other data. The ETA, SPE and DPC in 2018 are main topics of this study.

Jürgen Rendtel Poster

Geminids 2018

Activity during the 2018 return is analysed from visual and video data. Peak rates are discussed in the context of high peak ZHRs observed over the recent years.

Janko Richter Friday 17:40–18:00

How to test whether the magnitude distribution of the meteors is exponential

Very often it is assumed that the magnitude distribution of meteors is exponentially distributed. Under these conditions, the ZHR and the population index are estimated from visual observations. But is the observed magnitude distribution really exponential? Is there any way to verify that, even if the perception probabilities are not known? This talk will show how stochastic methods can be used to easily perform these checks. We will clearly see from the visual observations of selected showers that in most cases it cannot be assumed that the magnitude distribution of the meteors is exponential.

Athleen Rietze Friday 17:25–17:40

De-Biasing of meteor radiant distributions obtained by the Canary Island Long-Baseline Observatory (CILBO)

A. Rietze, D. Koschny, G. Drolshagen, B. Poppe

CILBO is a double-station camera setup for meteor observations and a project by ESA's Meteor Research Group at ESTEC, Noordwijk, the Netherlands. It is an automated system consisting of two stations with image-intensified video cameras. While one station is located on La Palma and the other camera on Tenerife, they both point at the same position in the sky at a height of 100 km. With this overlap of the two observation volumes which is covered by both stations it is possible to track meteors and to analyse their trajectory.

The data available for an analysis was collected by CILBO from December 2011 until January 2018.

In this presentation, the relative number of the sporadic meteors depending on their velocity and their mass is shown. Also, the method of de-biasing the data by comparing it to a velocity distribution model for every velocity bin in every mass bin is explained. We refer to a model based on radar in in-situ observations for 100 km altitude (ECSS, 2008). The consequent results of the de-biased meteor radiant distribution are shown.

Regina Rudawska Sunday 09:30–09:45

ESA's activities on fireballs in Planetary Defence

R. Rudawska, N. Artemieva, J. L. Cano, R. Cennamo, L. Faggioli, R. Jehn, D. Koschny, R. Luther, J. Martín-Ávila, M. Micheli, K. Wünnemann

Since Jan 2009, European Space Agency (ESA) has a so-called 'Space Situational Awareness' programme, addressing, among other points, the topic of Planetary Defence. Planetary Defence means to ensure that we know about asteroids potentially hitting our planet, and what to do about it. However, among services provided via a technical portal at `http://neo.ssa.esa.int` a Fireball Information System (FIS) will be accessible in the near future. Once completed it will provide a comprehensive entry point to relevant information (time, location, brightness, images, videos, etc.) on observed fireballs events since 2010 having visual magnitude magnitude brighter than -10. Moreover, within other Planetary Defence activities on fireballs are deployment of space-based fireball camera and creation of an impact effects knowledge base and an impact effects simulation tool.

Peter C. Slansky Saturday 09:00–09:25

3414-2018: A Perseid Fireball with exceptional Light Effects

Fireball 3414-2018 showed exceptional Light Effects, including a bright Terminal Flash, green Afterglow, Persistent Train and a widespread Sky Glow, observed with various Observation Techniques by amateurs. Especially the video observation by the author with a camera with a high sensitive color CMOS sensor in full HD resolution revealed new results such as extraordinary areal dimensions of the terminal flash and its green afterglow as well as a widespread bluish sky glow.

Peter C. Slansky Saturday 11:40–12:00

The Bridge of Spies

The Glienicker Brücke, built in 1907, connects the south-western Part of Berlin with Brandenburg. In the era of the Cold War it was used three times to exchange captured spies between NATO and the Soviet Union. Many feature films referred to this very special place at the border between the two blocks of the Cold War including 'The Bridge of Spies' (2015) directed by Steven Spielberg with Tom Hanks as a leading actor. The talk shall take place just before the excursion on the Glienicker Brücke. It shall stress, that peace and international collaboration are not self-evident.

Travis Stenborg Poster

Meteor Candidate Observations from Automated Sampling of Weather Cameras in VBA

A VBA program was developed to continuously sample an adjustable set of publicly accessible webcams for meteor activity. A test set of all sky cameras and regular webcams, heterogeneous in their image quality, low light sensitivity and image refresh rates was compiled. Automated night sky monitoring was then performed on nights before, during and after the Perseid peak from locations around Australia. The combination of low radiant altitude and bright time conditions yielded no unambiguous Perseid detections. As the Perseid peak overlaps other southern sky meteor showers, with higher radiant altitudes, serendipitous capture of non-Perseid meteor candidates was made. Weather cameras on the sparsely-populated Norfolk Island proved to be especially effective, having amongst the best image resolution and low light sensitivity of the webcams sampled.

Mohammed Talafha Friday 14:45–15:05

Double and Triple Meteor Detections

Anas Omar Adwan, Yousef Eisa Yousef Doostkam, Ilias Fernini, Ridwan Fernini, Ahmad Hassan Harriri, Issam Abu-Jami, Yahya Al-Nahdi, Hamid Al-Naimiy, Masa Al-Naser, Aisha Al-Owais, Maryam Sharif, Salma Subhi, Mohammed Talafha, Shahab Zarafshan

A prominent meteor monitoring network known as the UAEMMN was developed in the United Arab Emirates in September 2018. The network consists of three towers located in different parts of the country, each equipped with 17 cameras of different lenses. The total number of meteors observed as of June 2019 is 9,992 with 956 being double detections, and 86 triple detections. Furthermore, we are developing a smart UAV to detect meteorites at the possible meteorite landing sites.

Juraj Tóth Saturday 09:55–10:15

AMOS and interesting fireballs

AMOS (All-sky Meteor Orbit System) is an image-intensified all-sky video meteor system originally developed for the Slovak Video Meteor Network in 2007 at the Astronomical and Geophysical Observatory in Modra (AGO) of the Comenius University (Tóth et al., 2011, Zigo et al., 2013). Currently, five stations are operational in Slovakia and two on Canary Islands since March 2015 (Tóth et al., 2015). A pair of AMOS cameras were installed in Chile in March 2016 (Tóth et al., 2016) to monitor the meteor activity on the southern sky. Another pair of AMOS cameras were installed on Hawaiian Islands: atop of Haleakala and Mauna Kea. I will present some interesting fireballs observed by AMOS in the past.

Ozan Unsalan Sunday 09:55–10:20

Evidence of shock metamorphism in Bursa L6 chondrite: Raman and Infrared Spectroscopic Approach

Ozan Unsalan, Cisem Altunayar-Unsalan

The main goal of this study is to identify the mineralogical composition of the Bursa L6 stony chondrite and investigate its shock stage by Raman and Fourier Transform Infrared spectroscopic techniques. The very well-known characteristic doublet band of olivine was detected at 820/852 cm^{-1} in the Raman spectrum and the forsterite composition of the Bursa L6 chondrite was derived to be 75%. The Raman spectroscopic part of this study showed the presence of plagioclase feldspar pyroxene signals, ringwoodite (high-pressure polymorph of olivine), maskelynite and augite. From Infrared spectroscopic data we obtained, the existence of maskelynite was confirmed. A detailed discussion was given on the possible shock stage of the Bursa chondrite, based on the band profiles in Raman spectrum we suggest pressures at least higher than 35 GPa.

Jeremie Vaubaillon Sunday 10:40–10:50

Update on the MALBEC project

Jeremie Vaubaillon, Antoine Caillou, Philippe Deverchere, Danica Zilkova, Apostolos Christou, Jacques Laskar, Mirel Birlan, Benoit Carry, Francois Colas, Sylvain Bouley, Lucie Maquet, Pierre Beck, Pierre Vernazza

The 'Meteor Automated Light Balloon Experimental Camera' (MALBEC) aims at observing the meteors from stratospheric altitudes in order to make sure the clouds do not prevent the observation. Technical development has been the focus of the work so far. This talk will present the preliminary results.

Cis Verbeeck Friday 10:45–10:55

BRAMS forward scatter observations of major meteor showers in 2016-2019

Cis Verbeeck, Hervé Lamy, Stijn Calders, Antonio Martínez Picar, Antoine Calegaro

The BRAMS network consists of a dedicated forward scatter beacon and about 30 forward scatter receiving stations located in or near Belgium. Though these stations perform observations all year round, we still need the help of citizen scientists from the Radio Meteor Zoo for accurate detection of complex overdense meteor echoes observed during meteor showers. From 2016 onwards, we organized Radio Meteor Zoo campaigns for the major showers. Here, we present and compare activity curves from BRAMS forward scatter observations of major showers in the years 2016-2019. The estimated shower component is obtained after subtracting an estimate of the sporadic background. The results are still preliminary, as this study does not yet include correction for the sensitivity of the setup as a function of the radiant position (the Observability Function).

Bill Ward Friday 14:10–14:25

A spectral mystery

Analysis of an 'unmeasurable' spectrum taken by E. Majden, Canada, in 1997.

Mariusz Wiśniewski Saturday 09:25–09:35

Results of Polish Fireball Network in 2018

Mariusz Wiśniewski, Przemysław Żołądek, Arkadiusz Olech, Arkadiusz Raj, Zbigniew Tyminski, Maciej Maciejewski, Karol Fietkiewicz, Maciej Myszkiewicz, Marcin P. Gawroński, Tomasz Suchodolski, Marcin Stolarz , Mariusz Gozdalski

The Polish Fireball Network (PFN) is a project to monitor regularly the sky over Poland in order to detect bright fireballs. During 15 years of PFN operation 570 968 meteor events were recorded. In 2018 the PFN consisted of 38 continuously active stations with 68 sensitive analogue video cameras and high resolution digital cameras recorded 82 247 meteor events. Using the PFN data from 2018 and the UFOOrbit software 15 296 trajectories and orbits were calculated.

Przemysław Żołądek Saturday 09:35–09:55

Beta Taurids video campaign

Przemysław Żołądek, Arkadiusz Olech, Mariusz Wiśniewski, Marcin Bęben, Hubert Dróżdż, Marcin Gawroński, Karol Fietkiewicz, Artur Jaśkiewicz, Mirosław Krasnowski, Henryk Krygiel, Maciej Kwinta, Janusz Laskowski, Zbigniew Laskowski, Tomasz Łojek, Maciej Maciejewski, Maciej Myszkiewicz, Piotr Nowak, Piotr Onyszczuk, Krzysztof Polak, Krzysztof Polakowski, Arkadiusz Raj, Andrzej Skoczewski, Mariusz Szlagor, Zbigniew Tymiński, Jarosław Twardowski, Walburga Węgrzyk, Paweł Zaręba

The short description of the Beta Taurids video campaign conducted by PFN between 20.06.2019 and 15.07.2019. Preparations, equipment and preliminary results are presented.