Minutes of the annual METRO meeting

Participants

- Hervé Lamy (BIRA, meeting chair)
- Stijn Calders (BIRA, reporter)
- Johan De Keyser (BIRA)
- Pierre Ernotte (EPHEC)
- Paul Roggemans (IMO)
- Jan Thoemel (BIRA)
- Michel Anciaux (BIRA)
- Sylvain Ranvier (BIRA)
- Gerhard Drolshagen (ESA)
- Apostolos Christou (Armagh Observatory)
- Jean-Louis Rault (IMO)
- Federico Bariselli (VKI)
- Vincent Giovangigli (VKI)
- Thierry Magin (VKI) (until lunch)
- Jacy Scoggins (VKI)
- Bruno Dias (VKI)
- Cis Verbeeck (ROB) (after lunch)

Excused

- Cédric Tétard
- Jérémie Vaubaillon
- François Collas

Location

Royal Belgian Institute for Space Aeronomy - Nicolet Room 1
Avenue Circulaire 3
1180 Uccle
Belgium

Date

Thursday 16 November 2017

Welcome

Johan De Keyser opens the meeting and welcomes everyone.

The minutes reflect mainly the discussions during the meeting. The PowerPoint slides of all presentations and the program are available online.

Status of the BRAMS network – Hervé

- Jean-Louis wants to discuss with Antoine Calegaro (former IT student who did an internship in 2017) about the issues he experienced with the implementation of a radio meteor receiving station using a FunCube dongle and a Raspberry Pi. Hervé will put them in contact.

A new automatic detection algorithm for radio meteor echoes – Hervé

- Gerhard Drolshagen asks what the bright blob on slide 15 around the beacon frequency might be. Hervé says it has a long duration and it is quite bright, so he believes this is a real meteor. He mentions also the double Doppler effect that can explain why the radial speed seems to be low.

- Jean-Louis Rault asks why we don't apply an upper limit in the vertical extent. Hervé answers that he is able to filter out broadband interference by detecting them using the same technique in a bandwidth of 200 Hz located 100 Hz above the beacon frequency (so where no interesting signal appears). So broadband interference is not an issue for the detection algorithm.

- Gerhard Drolshagen asks why a minimum width of 3 or 4 has been chosen. Hervé mentions that the width is dependent on the time resolution we obtain with the FFT parameters used. In our case we take 16384 samples and an overlap of 90%. So the time resolution is approximately 0.3 second. Because of the overlap, a meteor cannot happen on a single pixel.

- Johan De Keyser mentions that in principle, three parameters should be sufficient. The threshold for the length of the remaining objects in the binary image should depend on the width of the median filter used. Hervé agrees and he will investigate this further.

- Pierre Ernotte asks if there are examples of planes intersecting with a meteor. Hervé answers the he doesn't remember to have had issues with that in this algorithm. Moreover he says that there won't be any perfect solution, and 10% false positive rate is acceptable.

- Pierre Ernotte asks if he tried the algorithm during a meteor shower. Hervé says no but that for the meteor showers, on the short term, the data will be processed by volunteers in the Radio Meteor Zoo. On the long term we should keep investigating automatic detection algorithms.

- Apostolos Christou asks how well we can simulate an airplane reflection. Jean-Louis Rault answers that this is easy for commercial flights for which trajectory and speed are easy to access

online. Jan Thoemel mentions that we could then try to detect planes instead of meteors in order to filter them out. However, for military planes (our beacon is close to a military airport), the shapes of the plane reflections are very complex due to constant changes of trajectory and speed. And information about these trajectories cannot be obtained. For commercial flights, we may try it next year with a student.

- Jacy Scoggins mentions that there exists image convolution methods to remove noise and to reconnect broken structures (e.g. to reconnect the interference pattern in plane reflections). Hervé answers that this is a good idea to detect and remove planes, but then you lose also the intersecting meteors. Jacy will send some references to Hervé about these image convolution methods.

Coffee break

First results and calibration of the BRAMS radio interferometer – Hervé

- Johan De Keyser asks if the stability of the phase was also investigated for a plane echo. Hervé says it is a good idea and planned.

- Gerhard Drolshagen asks what the expected accuracy of the direction is. Hervé answers that it will be in the order of 1°. This accuracy will be only for the interferometer, not for the other stations. We have plans to construct another interferometer in Dourbes, about 60 km from Humain, as part of the meteor radar. The frequency will be slightly different but only a few KHz, so we could compare the results and obtain directions of two reflections points when the geometry is adequate. But first we have to combine the results from the interferometer with data from other BRAMS "classical" stations (i.e. measuring time differences between the appearances of the various meteor echoes). There are a few stations that detects the same meteors as the interferometer in Humain, but extra stations in the neighborhood of Humain is advisable as this will increase the number of common detections between Humain and at least 3 other stations.

Simulation of atmospheric entries of meteors in the continuum and rarefied regimes – Thierry Magin, Federico Bariselli, and Bruno Dias

- New development is
    - the provision of a new solver on the chemistry, which will allow to couple to the radio problem
    - experimental work to obtain data for validation of the codes
- Multiphysics problem
    - Lagrangian solver to compute the electron density
        - Production of free electrons, diffusion, recombination

        - There exist models for scattering
            - Simple trail modeling as a cylinder or a cone
            - Density of free electrons as a function of meteoroid velocity, meteoroid ablation rate, effective ionization coefficient
            - Received power also depending on ground system configuration
        - Maxwell transfer equations
            - Boltzmann equation has a convective and a diffusive operator part, and a reactive collision operator
            - Just take averages of the Boltzmann equation
            - Approach is valid for DSMC and CFD regimes, i.e. same equations but fluxes come from different sources
- Boltzmann equation
    - Boundary condition
        - Flux from the object surface = flux due to evaporation + reflection (backscatter)
        - Particles evaporate at the equilibrium vapor pressure (but there is no equilibrium)
    - Meteor ablation experiments at NASA
        - Checking the models
- DSMC model
    - With short time steps, the motion of particles in the domain is followed, while the collisions are treated stochastically.
    - Use SPARTA, an Open Source DSMC code, parallel, with mesh refinement
    - Attention with the interpretation of temperature, where you have superposed streaming and back-streaming particles; there are rather infrequent collisions between both groups
    - There seems to be thermal equilibrium in the trail
    - Strong shielding at the front by ablating particles, recondensation becoming more effective in the trail at lower altitudes
- Lagrangian reactor
    - In DSMC the chemistry treatment has to be simplified for computational reasons
    - Also with CFD the chemistry becomes computationally costly
    - Therefore treat chemistry a posteriori
        - Use the streamlines from the dynamic model
        - The detailed chemistry does not feed back into the dynamics
    - Extension to 2D
    - Recombination
    - Diffusion, only in the radial direction
    - Check of plasma frequency versus the obtained electron density
    - You can extend this to very long trails
    - The trail thermalizes after about 15 object diameters
- Coupled flow – chemistry – radiative equilibrium

    - Hybrid Statistical Narrow Band model = combination of narrow band discretization plus discrete lines = computationally much cheaper
    - Ablation model incorporates the species surface mass balance and the surface energy balance
    - Use of the Knudsen-Langmuir law describing evaporation rate
    - Experiments at NASA Ames – interest in big impactors and their effects, showing the molten layer removal by shear forces
    - Simulations require flow-material coupling
    - Relative importance of convective and radiative heat transport can be studied

- Johan De Keyser asks what it means to have an equilibrium at the surface. Federico clarifies it doesn't mean that you have equilibrium between the gas and the wall.

- Jean-Louis Rault asks if there is a simulation of a regular turbulent trail. This could explain the irregular oscillations in the signal reflection. Bruno says it could be because the meteoroid body is rotating. This is not simulated.

Thierry Magin (VKI) leaves the meeting.

Lunch

Cis Verbeeck (ROB) joins the meeting.

After lunch Bruno Dias continues presenting his work.

- Vincent Giovangigli asks: "how do you calculate α_i in the Knudsen-Langmuir equation?" Bruno answers that for the moment they assume a value.
- Apostolos Christou asks how mechanical removal works. Bruno answers that the liquid is blown off the surface of the meteoroid.
- Gerhard Drolshagen asks to comment on the velocity dependence on the ionization level. Federico answers that sometimes they see higher ionization levels at lower speeds. For a very high velocity, the cross section becomes small, causing less collisions.
- Johan De Keyser asks about the integrated electron density. Is it a monotonic function? Federico answers this is not always the case.
- Gerhard Drolshagen mentions that the peak luminosity is related to the speed: the faster the meteoroid, the brighter the meteor (at least in optical wavelengths). Johan De Keyser mentions that we are in a completely different regime. In the optical wavelengths, you are in thermal equilibrium.

CAMS coverage for BRAMS meteor echoes – Paul Roggemans

- Hervé Lamy mentions that he has a contact point in the north of France, close to Germany. He will check if they are motivated to install a CAMS camera.
- Federico Bariselli asks if Paul tried to compare the altitude of the maximum brightness with trajectory simulations (ablation models). Paul said no.

- Bruno Dias asks what the minimal size of the meteoroid is. Paul answers that they have only a limit to the brightness: a very slow one can go up to magnitude 5, a fast one up to magnitude 4.

- Bruno Dias asks if there is public access to the results. Paul confirms that you can see the results on the website of SETI CAMS (http://cams.seti.org/).

- Apostolos Christou comments that the gap between the geocentric velocity distribution can be explained because of two groups of comets: Jupiter family comets and long period comets. He will send a reference to Paul about it.

- Gerhard Drolshagen asks if the geocentric velocity distribution graph is both for sporadic and stream meteors. Paul confirms: he didn't make the distinction between these two groups.

- Apostolos Christou mentions that Jupiter family comets don't produce necessarily Jupiter family meteoroids, especially for older particles. Fresh material should however be Jupiter family meteoroids. In summer and autumn meteoroids are linked to long period comets, while in winter and spring they are more linked to Jupiter family comets.

- Gerhard Drolshagen mentions that there is an observation bias towards fast meteors. We should keep this always in mind in the interpretation of the observed distributions.

- Hervé Lamy asks when the new CAMS code will be made available. Paul says that he is still dealing with some software bugs, and that he doesn't want to release before these are solved. He is currently in contact with Pete Gural to fix the software.

Comparison between CAMS and BRAMS observations – Cédric Tétard

(Hervé presents the results on behalf of Cédric.)

- Sylvain Ranvier asks if the assumption of the specular reflection is correct for overdense meteors. Hervé is confident that this is still the case, except for some bigger objects for which we might be able to detect non-specular reflections first.

Status of the optical and radio FRIPON networks – Jean-Louis Rault

- Hervé Lamy asks if FRIPON can get high accuracy if the meteor is close to the horizon. Jean-Louis says that they exclude meteors below 10° elevation, also because the city lights distort too much the observations.

Jacy (VKI) leaves the meeting.

- Bruno Dias mentions that one head echo (disappearing suddenly) could be caused by an airburst.

- Cis asks why some big meteors produce head echoes, while others don't. Probably the objects must follow a highly inclined path such that the forefront ionized area can efficiently reflect the radio wave. In any case it is an interesting problem to solve where geometry plays a major role.

- Jean-Louis shows that sometimes the head echoes are oscillating, which means that the object is alternately approaching and moving away. Hervé Lamy asks what the bandwidth of the oscillation is. Jean-Louis answers it is about 2kHz. Federico Bariselli and Gerhard Drolshagen suggest it is an instability in the plasma, not because of a rotating body (the frequency is too high for that). Sylvain Ranvier asks if it is not due to the modulation of the transmitter. Jean-Louis says it is certainly not the case. Bruno Dias asks how frequent this phenomenon is. Jean-Louis answers between 2 and 4% of the observed head echoes.

- Gerhard Drolshagen mentions that, at the IMC, Denis Vida (CMOR) has presented a high-speed camera using an automatic tracking system. He mentioned that all bolides that this system has detected are fragmenting.

A Ray-Tracing Technique for Reentry Plasmas – Jan

- Problem studied is radio blackout during high speed atmospheric reentry (for Mars)
- From the flow simulation, one establishes the breaking index
- Then do ray tracing using Snell's law
- Example for a reentering body : waves from an omnidirectional antenna initially remain bounded in the wake, with a lot of reflection and refraction; later on the radio waves are undisturbed; all depends on the frequency used vs. the electron densities
- For meteors, application to the trail, you find specular reflection

Method is potentially more useful in complicated flow fields, for head echoes, time-dependent features, etc.

Johan leaves the meeting.

Radio Meteor Zoo – Stijn Calders

No questions or remarks.

Results from the Radio Meteor Zoo for a few main meteor showers – Cis

No questions or remarks.