Annual Meeting METRO – 27 october 2015 – Minutes

Project BRAIN-BE BR/143/A2/METRO

Location : Belgian Institute for Space Aeronomy

Present:

H. Lamy, M. Anciaux, J. De Keyser, E. Gamby, S. Calders, C. Tetard (BIRA-IASB)

A. Martinez (KSB-ORB)

Thierry Magin, Bruno Dias, F. Bariselli (VKI)

J.L. Rault (IMO)

Th. Cristo (Armagh)

G. Drolshagen (ESA/ESTEC)

P. Roggemans (IMO, CAMS-BeNeLux network)

J. Vaubaillon (IMCCE)

Excused:

D. Cocx (BELSPO/BRAIN-BE)

V. Giovangigli (Ecole Polytechnique)

Ph. Claeys (VUB)

The meeting starts at 10 am. H. Lamy says a word of welcome, and everybody presents himself.

J. De Keyser gives a presentation to highlight the different aspects of the interest of BIRA-IASB scientists in meteor science, including the link to comets (Rosetta) and to upper atmosphere composition. There is time for a few questions.

H. Lamy gives an overview of the BRAMS network and the equipment used. Emphasis is on the time calibration using GPS, on the signal frequency and intensity calibration using the BRAMS calibrator and on antenna sensitivity pattern measurements using a drone. The installation of the Humain interferometer is discussed, as well as the measurement of phase differences between the signals from the individual interferometer antennas.

H. Lamy also discusses WP 1.1 about the automatic detection of meteor echoes in the huge volume of data retrieved each day, highlighting some of the successful efforts done in algorithm development. The indicator-signal-based algorithm (developed by Tom Roelandts) has been tested in detail. Results show that the method can miss as little as 10% of the meteors, but at the expense of a considerable number of false positives. Fine-tuning the parameters of this method is not easy. So a new method has been investigated and presented . It is based mostly on the spectral signature difference between airplane reflections and meteors and using a window median filter to filter out the former.

Questions : G. Drolshagen asks what we are actually measuring : it is the power reflected off the meteor trails (except for head echoes). There is also a discussion regarding the unicity of the trajectory solutions.

Measurement of the velocity should be possible from the time of appearance of the reflection points observed at different stations. Speed can also be obtained from the Fresnel oscillations or from head echoes. Discussion about the precision that could be achieved. Our goal is to try to compare with CAMS or FRIPON data but these concern optically bright meteors that correspond mostly/only to overdense meteor echoes in BRAMS data. G. Drolshagen emphasizes the need to determine the velocity as good as possible.

Another question is about the possible natural perturbations : airplanes, lightning, sporadic E reflection. An issue is how to eliminate planes from the signal waveform.

The contribution from man-made space debris is also discussed. Typically one major object is re-entering each day somewhere on Earth.

C. Tetard presents WP 1.2 results on multipoint trajectory determination (geometrical, timing, or assisted). The presentation focuses on the assisted trajectory determination using the interferometer (following Jones et al., 1999). The problem of the phase ambiguity and possible solutions are discussed using an actual example, so as to determine the direction of the reflection point. The height of the reflection point can be obtained e.g. from the underdense decay rate combined with a good atmospheric model. Using additional simple BRAMS stations we can then obtain the trajectory. Some results are presented, showing a clear phase coherency whenever a bright meteor echo appears in the data and very noisy results otherwise (as expected). The accuracy achieved on the phase angle is around 1°. Problems can arrive when a plane signal or the direct signal from the beacon superimposes on the meteor echo, hence modifying its phase in a not easily predictable way. There is also a discussion on how to choose the frequency of a meteor echo for the phase difference measurements (i.e. integrated along the frequency profile of the meteor, maximum intensity along the profile, etc. …) An example of a C-meteor and a complicated epsilon meteor are also given. Conclusion : the Jones method seems to work well with BRAMS. Further validation to check the direction of arrival of the signal is needed. For these tests the drone equipped with the BRAMS calibrator will be used. The challenge will be to obtain a robust and automatic technique that is capable of rejecting contamination from the plane echoes.

J. Vaubaillon presents the status of the FRIPON network. French project extended now to Belgium for the METRO network. FRIPON = Fireball Recovery and Planetary Observation Network. The goal of the network is explained. Light pollution is no issue for fireballs. The hardware of the cameras is presented. Cameras work during night and day. PoE power provision with a single cable. Open source software is available for the detection software (https://github.com/fripon/freeture). The procedure foresees removal of airplanes and satellites. Multiple meteor detection occurs frequently. From these one can determine the trajectories. Accurate trajectories are directly needed if you want to go back to the original orbit of the object. Combining radios and optical measurement techniques is therefore very useful. The uncertainty in meteorite fall location due to the role of wind during dark flight is estimated using simulations. Meteor spectra offer a way to establish the composition; so there is a development underway of a spectrograph. Seismic signals are recorded of the compression wave traveling through the atmosphere. There is a people network for doing a field search after a reported meteorite fall.

Noon break – lunch in the canteen

At 13:30 P. Roggemans presents the CAMS BeNeLux network. The main CAMS in the US has already obtained lots of orbits. Still , it is useful to have a network in Europe to have a better coverage in longitude for very short-lived streams. All stations use the same type of Watec camera and optics. Video (https://vimeo.com/12836) showing comet dust evolution along the orbit and orbit modification. These cameras are rather insensitive to light pollution (more infrared sensitive. Every morning, a manual check of the meteor candidates must be done to eliminate birds, planes, (clouds are almost automatically rejected). Data processing is rapid and automatic. Products : progenitor orbits, position of the trail, light curves afo altitude, … Paul has examined how to best position (in azimuth and elevation) the CAMS cameras to be complementary to BRAMS. With three cameras : Dourbes to Maastricht, Dourbes to Lille, Ukkel to Lille. Alternatives can be explored. Remote camera operation is also becoming possible.

Th. Magin reviews the von Karman Institute research activities on atmospheric re-entry flows and how that relates to the meteor work in METRO. The required simulations are complex multi-physics problems with heat conduction, radiation, gas-surface interaction, rarefied gas effects, … New materials : PICA carbon phenolic resin components. With porous TPS materials : you can no longer ignore diffusion inside these materials. One has to incorporate microscopic structure in macroscopic simulations. Uncertainty quantification is also very important. Ground-testing of TPS materials carbon fibres, or carbon-resin materials. One would then need compatible parameter settings (including compatible chemical reactions) similar to the real-world situation. VKI has a plasmatron to do such simulation experiments. Various kinds of instrumentation is foreseen. A high speed camera allows to see the recession speed of the ablating material; there are three spectral windows. Numerical simulation codes are in a library. There is the Mutation++ tool for managing the thermodynamic and transport and reaction kinetic and radiation database. A first simulation technique is to reduce the Navier-Stokes equations to the stagnation line. The treatment of the radiative transport is based on a statistical narrow-band model, in which you combine a line-by-line treatment of atomic lines and an averaged statistical treatment for the molecular spectra. A second possibility is a multi-dimensional code (Argo) for porous media. Studies have been done of the flow transition from laminar to the turbulent regime near the eroded wall. There is the QARMAN cubesat under development, with instrumentation, to directly measure re-entry properties. From flight experiments one can ideally reconstruct the atmospheric properties. Then questions arise about the required uncertainties of sensors. For the high altitude regime, rarefied gas dynamics is needed. Issues such as coupling rarefied regime and continuum methods have to be dealt with.

Discussion : meteor ablation can be simulated in the lab, but needs special facilities if one wants to go to very high entry velocity. The idea is to test in the VKI plasmatron with a real meteorite.

B. Dias presents some of his results on the stagnation-line simulations of meteor ablation. The electron density in the trail comes from the ionization in the stagnation region. Depends on possible reactions of ablation products with the gas. Some ionization can actually occur before the shock due to radiation. Chemical equilibrium is assumed to compute the blowing. The energy balance of the wall is used to obtain the wall temperature. The flow field can be modelled with as major element the shock. Temperatures of > 100 K can be used. Multiple ionisation will play a role. Use of the simplified radiation problem makes it tractable. The 1D code is in spherical coordinates. The model is used at relatively low altitude to justify the continuum regime. The results show the stand-off distance of the shock layer, temperature, composition, etc.

There is a discussion about how to constrain the elemental composition in the ablation process; this is likely related to the porosity or the diffusivity of the material, mixing, … For big meteors, melting and fragmentation might be important.

There is clearly a challenge in going to the rarefied regime to model meteors at higher altitude, in order to model the whole meteor flight.

Suggestion is to focus first on stream meteors, where a number of things are known a priori, and on things that can be measured.

G. Drolshagen emphasizes the importance of quantitative fluxes. How does the observed "brightness" depend on the velocity? That is often a strong dependence, and will influence the data analysis. This is a crucial element to obtain fluxes in space. H. Lamy adds the importance of the observability function. Some work has already been done on this with the help of S. Calders and C. Verbeek (ROB).

J. De Keyser and H. Lamy thank the participants. The meeting ends around 15:30.