EPSC Abstracts
Vol. 12, EPSC2018-1062, 2018
European Planetary Science Congress 2018

A spectroscopy pipeline for the CILBO meteor detection system

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Meteor spectra provide valuable information on the chemical properties of individual meteoroids [16, 1, 2, 17, 13, 11]. In some cases, this may be the only information on the chemical composition of the parent bodies, and on transforming processes that occur during the meteoroid's journey from its source to Earth. The CILBO spectroscopic program has been created with the intention of carrying out regular systematic spectroscopic observations. At the same time, the meteoroid trajectory and pre-atmospheric orbit are independently measured from data collected by the other cameras in the network. We will introduce and demonstrate the capability of the meteor spectroscopy pipeline developed by the Meteor Research Group of the European Space Agency and its application to the spectroscopic survey of meteors observed by CILBO, particularly the Geminid meteor shower.

1. CILBO meteor detection system

The Meteor Research Group (MRG) of the European Space Agency operates the double-station meteor camera system CILBO (Canary Island Long-Baseline Observatory). Currently, five image-intensified video cameras observe the night sky every clear night. Since full operations in 2012 [7] about 70 000 meteors have been observed. With two of the cameras (ICC7 and ICC9, set up on Tenerife and La Palma, respectively), we have recorded almost 20000 double-station meteors [5]. The recently installed large field-of-view cameras (LIC1 and LIC2) typically record between 1300 and 1700 meteors per month. The 3D trajectory and heliocentric orbits of these meteoroids were computed, and stored in the Virtual Meteor Observatory (VMO), which is the long-term archive of the International Meteor Organisation's video meteor camera network [6, 8]. Meteor orbits are computed using the MOTS code (Meteor Orbit and Trajectory Software) [4]. In the last years, the system was upgraded to include the recording of meteor spectra [3], operating image-intensified camera with objective grating (ICC8).

2. Meteor Spectroscopy Pipeline

The spectroscopy pipeline is divided into three steps. In the first step, cases with visible meteor spectra are selected. The second step is to retrieve the meteor spectrum from the raw images. Finally, in the last step, the meteor spectrum is analysed and modelled.

In the first step we preselect events that are used in the following analysis. For this purpose we use the MEteor Spectra Selector (MESS) software that goes over the ICC7 data mapping matching events in ICC8 data. At this stage, meteors with apparent magnitude lower than +3 are excluded, as meteor spectra for those cases are not detected by ICC8. The magnitude information is provided by `*.inf` files generated by MetRec [14] for events detected by ICC7. Moreover, from the same file, the pipeline software reads the pixel coordinates of the meteor that later are used to compute the expected spectral position in frames of ICC8. We analyse a box around the calculated position, where the signal-to-noise ratio and the absolute difference of intensity is computed. MESS creates the reference background image as median of 6 frames without meteor that MetRec additionally stores.

In the second stage, VIdeo Data Archiving System (VIDAS) [18] is used to perform the radiometric calibration by applying the dark current and flat field correction to each of the frames. The `*.inf` file of ICC7 contains for each frame the sky coordinates of the meteor (right ascension, declination). From this (RA, DEC) pair of ICC7, VIDAS computes the (RA, DEC) pair of each frame and each wavelength between 400 nm and 800 nm in steps of 0.5 nm. The (RA, DEC, wavelength) triple for each frame is then processed into a (x, y, wavelength) triple in the image coordinates. The spectrum is then computed by collecting for each frame from 400 nm to 800 nm the pixel value indicated by the (x, y, wavelength) triple.

At the last stage, the meteor spectrum is modelled using PARADE database (ESA's PlasmA RAdiation DatabasE) that undertakes a detailed assessment of the chemical species represented by each spectra. PARADE has been under development for several years [15, 12, 9]. It calculates the energy state transitions in atoms and molecules and the resulting emission. Originally developed for the purpose of the simulation of atmospheric entry plasma radiation in the atmospheres of Solar System planets and moons, it has been gradually expanded to include atoms and molecules measured in meteoroids [10]. Together with components of the air (O, N, N_2) the following elements are already implemented: Na, Mg, Fe, Ca, Cr, C, K, T, V, Mn, Ni, Co, Li, AlO, and TiO. A future update of the database will include more molecules, in particular FeO, MgO and CaO.

Acknowledgements

We acknowledge funding support from the faculty of ESA's Science Support Office.

References

[1] Borovička, J., Koten, P., Spurný, P., et al.: A survey of meteor spectra and orbits: evidence for three populations of Na-free meteoroids, Icarus174, 15, 2005

[2] Jenniskens, P.: Quantitative meteor spectroscopy: Elemental abundances. Advances in Space Research 39, 491, 2007

[3] Koschny, D., Albin, T., Drolshagen, et al.: Current activities at the ESA/ESTEC Meteor Research Group, Proceedings of the IMC2015, 204, 2015

[4] Koschny, D., Diaz del Rio, J.: Meteor Orbit and Trajectory Software (MOTS) - Determining the Position of a Meteor with Respect to the Earth Using Data Collected with the Software MetRec, WGN, 30, 87, 2002

[5] Koschny, D., Drolshagen, E., Drolshagen, et al.: Flux densities of meteoroids derived from optical double-station observations, Planet. Space Sci., 143, 230, 2017

[6] Koschny, D., McAuliffe, J., Barentsen, G.: The IMO Virtual Meteor Observatory (VMO): Architectural Design, Earth Moon and Planets, 102, 247, 2008

[7] Koschny, D., McAuliffe, J., Bettonvil, et al.: CILBO – Two years operation of a double-station meteor camera set-up in the Canary Islands, Proceedings of the IMC2013, 166, 2014

[8] Koschny, D., Smit, H., Barentsen, G.: The Virtual Meteor Observatory (VMO), Proceedings of the IMC2013, 133, 2014

[9] Liebhart, H., Herdrich, G., Merrifield, J. A., In: XLIII AIAA Thermophysics Conf. (Reston, VA: AIAA), 2012

[10] Loehle, S., Eberhart, M., Zander, F., et al.: Extension of the Plasma Radiation Database PARADE for the Analysis of Meteor Spectra, 2018 (submitted to Meteoritics and Planetary Science)

[11] Matlovič, P., Tóth, J., Rudawska, R., Kornoš, L.: Spectra and physical properties of Taurid meteoroids, Planet. Space Sci.143, 104, 2017

[12] Pfeiffer, B., Fertig, M., Winter, M., Auweter Kurtz, M.: PARADE - a program to calculate the radiation of atmospheric re-entry in different atmospheres. Radiation of High Temperature Gases in Atmospheric Entry, Vol. 533 of ESA Special Publication, 85, 2003

[13] Rudawska, R., Tóth, J., Kalmančok, D., Zigo, P., Matlovič, P.: Meteor spectra from AMOS video system, Planet. Space Sci.123, 25, 2016

[14] Molau, S., Meteroids 1998, 131, 1999

[15] Smith, A. J.: ESA PlasmA RAdiation DatabasE (PARADE). Development history, status, current developments and future, Radiation of High Temperature Gases in Atmospheric Entry. Vol. 533 of ESA Special Publication, 75, 2003

[16] Trigo-Rodriguez, J. M., Llorca, J., Borovicka, J., Fabregat: Chemical abundances determined from meteor spectra: I Ratios of the main chemical elements, Meteoritics and Planetary Science 38, 1283, 2003

[17] Vojáček, V., Borovička, J., Koten, P., Spurný, P., Štork, R.: Catalogue of representative meteor spectra, A&A580, A67, 2015

[18] Zender, J., Koschny, D., Ravensberg, K.: Calibration of spectral video observations in the visual: theoretical overview of the ViDAS calibration pipeline, Proceedings of the IMC2013, 126, 2014