

## **Supervisor's report on doctoral thesis by Mgr. Vlastimil Vojáček "Properties of faint meteors studied by video observations"**

PhD thesis of Vlastimil Vojáček are devoted to complex analysis of meteor data obtained by video techniques in scope of long-term program of the Ondřejov Observatory. A sample of about 150 meteors with completely observed luminous trajectories from two stations and, at the same time, spectra obtained along the whole trajectory was used for his work. The sample contains sporadic as well as shower meteors of various velocities. Heliocentric orbits of all meteors were computed and the origin of each meteoroid (asteroidal, cometary) could be therefore evaluated. The analyzed meteors were faint in comparison with fireballs traditionally studied at the Ondřejov Observatory, nevertheless, the average meteor brightness was about zero magnitude, i.e. we are dealing with meteors easily observable by the naked eye. Image intensified video technique is sensitive to fainter meteors, however, to obtain spectra of a reasonable quality, meteors brighter than magnitude about +2 were needed. To have an idea, the studied meteoroids were in the size range from millimeters to centimeters.

The complexity of data was the main advantage of the study. In the past, various methods of analysis of meteor video data were developed at the Astronomical Institute of the Czech Academy of Sciences in Ondřejov. They include spectral classification of faint meteors (Borovička et al. 2005), the erosion model for fragmentation of small meteoroids (Borovička et al. 2007) or, earlier, classification of faint meteors according to beginning heights (summarized in Ceplecha 1988). The goal of the thesis was to combine all these methods for a representative sample of meteors and use also other observable quantities such as preferential ablation of sodium or meteor morphology to get more insight about the structure and composition of small meteoroids and their interaction with the atmosphere (especially the mode of fragmentation).

Mgr. Vojáček mostly used software developed earlier in our department to analyze the data. He measured and calibrated all video sequences and computed meteor trajectories, velocities, orbits, and light curves. He also measured and calibrated all spectra. He improved the method by adding noise analysis. The calibrated spectra and their classification were published as a catalog in the journal *Astronomy and Astrophysics*. The paper was welcome by the meteor community and received already several citations. As a further step, meteor light curves and decelerations were fitted by the erosion model. Meteor morphologies, in particular the presence and length of wake, were evaluated for the first time from our data. Finally, monochromatic light curves in the main emission lines (Na, Mg, Fe) were studied from the spectra.

The data analysis took longer time than initially expected. It was found in between that the erosion model for fragmentation is not generally valid (Campbell-Brown et al. 2013). It is probably valid just for a subset of meteoroids, including e.g. Draconids. The erosion modeling was, nevertheless, kept in the work in order to see if the resulting model parameters correlate in some cases with some other findings, e.g. from spectral analysis. Mgr. Vojáček worked independently and checked many possible relations between results of different analyses.

Some earlier results were confirmed using this new dataset. These include e.g. the relations between spectral classifications and meteor beginning heights or between spectral and orbital classification. New findings were made as well, e.g. of a spectrum containing only atmospheric lines or of iron meteoroids in cometary orbits. Spectral classification of main meteor showers was presented for the first time, showing that most shower meteors have

mainstream spectra. Although the erosion modeling did not provide so clear picture as it was initially hoped for; it is encouraging that the grain size distribution in meteoroids with Jupiter-family orbits was found to be similar to the size distribution measured for dust particles emerging from comet 67P/Churyumov-Gerasimenko (as measured by the ROSETTA mission). Other important results are e.g. the finding that meteoroids which show early release of sodium tend to have smaller grains and that sodium poor meteoroids release their sodium early.

In summary, Vlastimil Vojáček proved, in my opinion, his ability to work independently with data and obtain new scientific results. I therefore suggest to grant him the PhD title.

Ondřejov, October 31, 2017

RNDr. Jiří Borovička, CSc.  
supervisor

Note: References in this report are the same as in the thesis.