α Monocerotid TV Spectra

R. Štork[1,2], J. Borovička[1], J. Boček[1], and M. Šolc[2]

[1]Astronomical Institute, Academy of Sciences of the Czech Republic, Fričova 1, CZ–251 65 Ondřejov, Czech Republic;

[2]Institute of Astronomy, Charles University Prague, V Holešovičkách 2, CZ–180 00 Prague 8, Czech Republic

September 8, 1998

Abstract

An outburst of α Monocerotid meteors was widely observed on November 22, 1995. Jenniskens et al. found that α Monocerotids penetrate deeper into the atmosphere than meteoroids of the Orionid stream or Perseid stream (meteoroids with similar velocity) and that their light curves do not show flares [5]. The Jenniskens' results imply that α Monocerotids are more compact than meteoroids in other showers and can therefore contain lower amount of volatile elements. We obtained four α Monocerotid spectra with our television system on the Ondřejov observatory [3, 6]. The spectra allowed us to test the above mentioned hypothesis. We found that the sodium line Na-I (589 nm) is very faint in all α Monocerotid spectra. The velocity of the meteoroids is 64 km/s but the spectra have a specific appearance different from both Perseids (61 km/s) and Orionids (67 km/s). The hypothesis concerning low amount of volatile elements could be confirmed, at least for sodium. The α Monocerotid TV spectra are presented together with a comparative statistical analysis with other showers. The dependence of meteor spectra on velocity is also discussed.

1 TV spectroscopy of meteors

If we wish to study a faint interplanetary material we have to either collect samples of it (IDPs, in situ measurement of probes to Comet Halley) or record the spectrum of meteoric light.

In second case only large bodies (fireballs) can easily be recorded photographically, but fireballs are a phenomenon too rare to be used for statistical comparative studies. This drawback can be eliminated by using more sensitive television equipment which is capable of recording of large number of spectra of smaller particles.

The second advantage of the use of television techniques instead classical photographic method is the good temporal resolution. On the other hand, the spatial resolution is lower.

The TV spectroscopy of meteors was started by the pioneering work of Millman et al. (1971). Further successful observations were performed in Ashchabad (Mukhamednazarov and Maltseva 1989). However, in general, relatively small attention has been devoted to this subject.

At the Ondřejov Observatory, regular TV observations of meteor spectra started in 1990. Now we have elaborated set of meteors spectra which is enough large for statistical processing.

2 Unique composition of α Monocerotids

The results of important relating work give hypotheses about features we can expect in our TV meteor spectra:

...

The double–station observations also provide clues regarding the structure of the dust particles within the α Monocerotid stream. They penetrate deeper into the atmosphere than meteoroids of the Orionid stream (P/Halley) or Perseid stream (P/Swift–Tuttle) and the light curves of the meteors do not show flares.

(From (Jenniskens et al. 1996).)

The Jenniskens' results imply that α Monocerotids are more compact than other showers meteoroids.

It can bear on lower amount of volatile elements and our α Monocerotid spectra allow us to test this hypothesis.

3 α Monocerotid spectra

Four α Monocerotid spectra were recorded on November 22, 1995.

α Monocerotids' velocity is 64 km/s but their spectra have specific visage unlike Perseids (61 km/s) and Orionids (67 km/s). The hypothesis concerning low amount of volatile elements (Section 2) is confirmed. The sodium line Na I-1 (589 nm) is very faint in all α Monocerotid spectra.

3.1 TVS 156

Only beginning of meteor was recorded at this case. The major part of meteor duration was out of the field of view. The prominent peaks on Fig. 1 are Mg I-2 (517 nm), Fe I-168 (650 nm) and O I-1 (777 nm). On

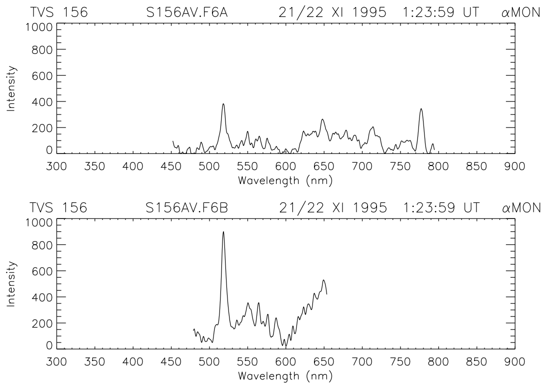

Figure 1: α Monocerotid spectrum TVS 156

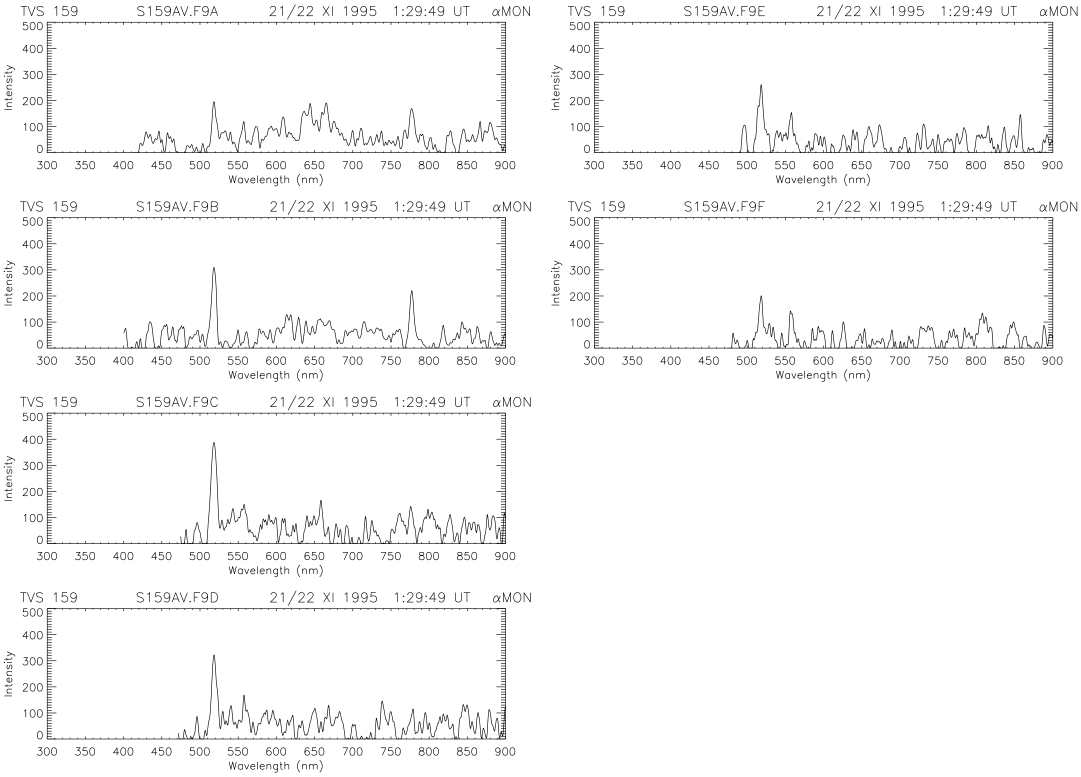

Figure 2: α Monocerotid spectrum TVS 159

second frame (recorded 0.04 s later) isn't recorded red part of spectrum but the absence of Na I-1 (589 nm) is evident here too.

3.2 TVS 158

This meteor flew to close to the edge of field of view and only blue rim of spectrum is recorded.

3.3 TVS 159

TVS 159 is faint spectrum with bad signal/noise ratio. But lines of Mg I-2 (517 nm) and O I-1 (777 nm) can be recognized. Na I-1 (589 nm) line which usually is as bright as Mg and O lines is absent again.

3.4 TVS 161

TVS 161 is our brightest α Monocerotid spectrum taken during the 1995 outburst. The prominent lines on Fig. 3 are Mg I-2 (517 nm) and O I-1 (777 nm). Although the N_2 belts (570–600 nm, 635–670 nm, 730–760 nm)

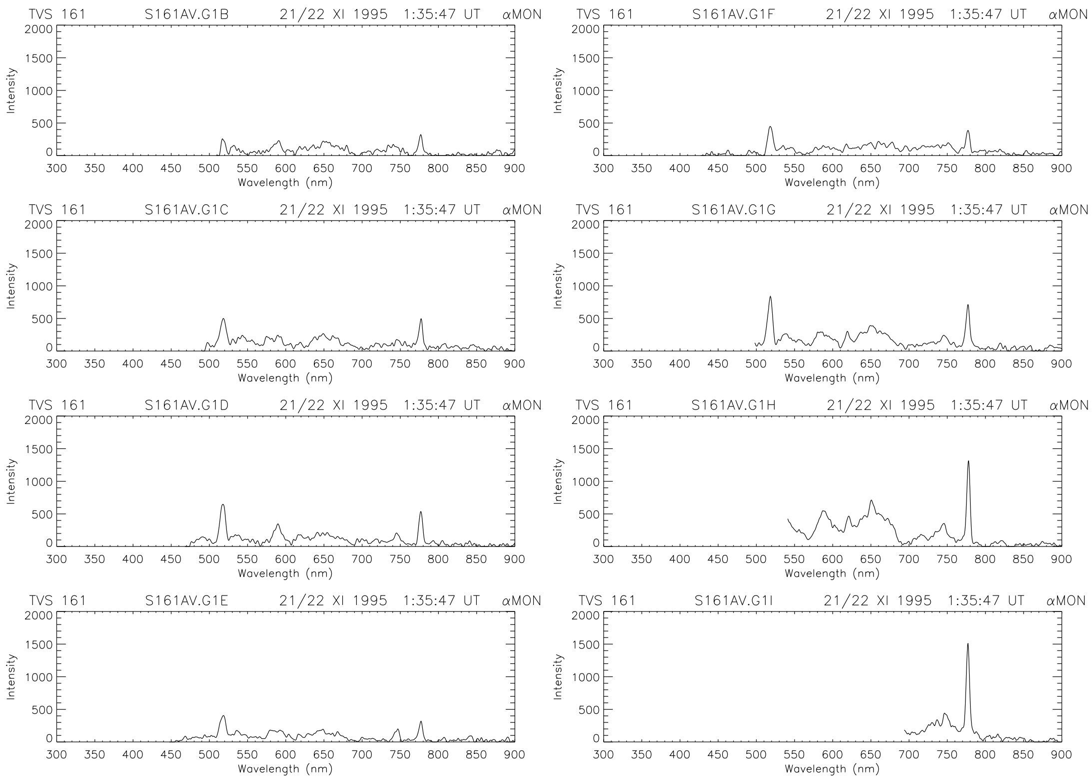

Figure 3: α Monocerotid spectrum TVS 161

and the faint lines O I-10 (616 nm), Fe I-168 (650 nm), N I-3 (745 nm) are visible the intensity of Na I-1 (589 nm) is very low.

4 Intensity plots

The spectra which examples are shown in Section 3 contain several lines. But only four lines were found to be enough bright in the significant number of recorded spectra and can be used for statistical processing.

We measure spectrum intensity at wavelengths 517.8 nm (Mg I), 589.2 nm (Na I), 746.8 nm (N I) and 777.4 nm (O I). The intensity is produced by scanning pixel intensities of the recorded image and is given in the relative units only.

Although the spectra weren't calibrated, the measured values were calibrated by spectral sensitivity of our technique at above mentioned wavelengths.

Following graphs show intensities in α Monocerotid spectra in comparison with other showers.

4.1 Na and O intensities

The points on Fig. 4 lie in the line and the meteor spectra show the correlation of Na and O lines. But some differences between showers are apparent.

The O I-1 line is fainter on slower meteors (Geminids and very slow meteor TVS 73). It's probably caused by strong dependence of second spectrum amount, which O I-1 belongs to, on the meteor velocity [2].

On the other hand, α Monocerotids have lower amount of sodium and corresponding points on Fig. 4 are shifted to the left.

4.2 Mg and Na intensities

The most important features of Fig. 5 are:

- The Geminid points are shifted to the right. Geminids are known to have lower amount of volatile elements due to their origin (asteroid 3200 Phaeton).
- The Mg I-2 intensity is low in the slow meteor spectrum TVS 73. It may be caused by higher excitation potential of this line (Mg I-2 2.72 eV, Na I-1 0.00 eV). In cases of higher velocities both lines are saturated and optically thick and this phenomenon isn't important.

5 Dependence on velocity

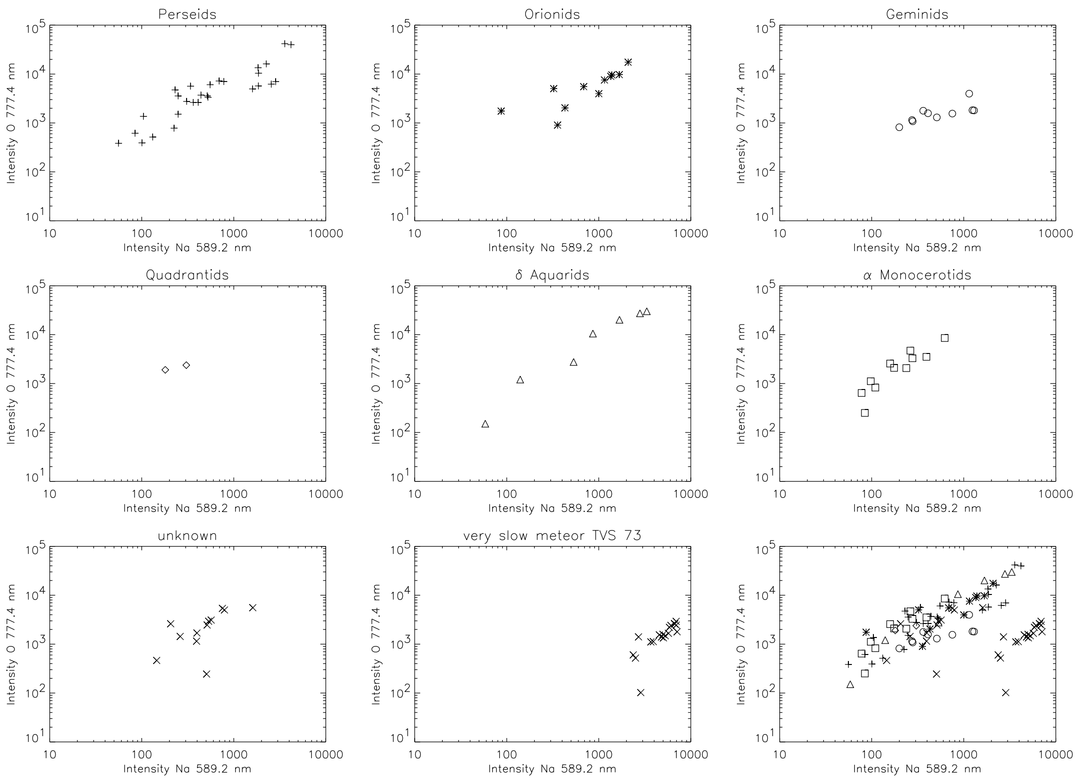

Figure 4: Na and O intensities in studied spectra

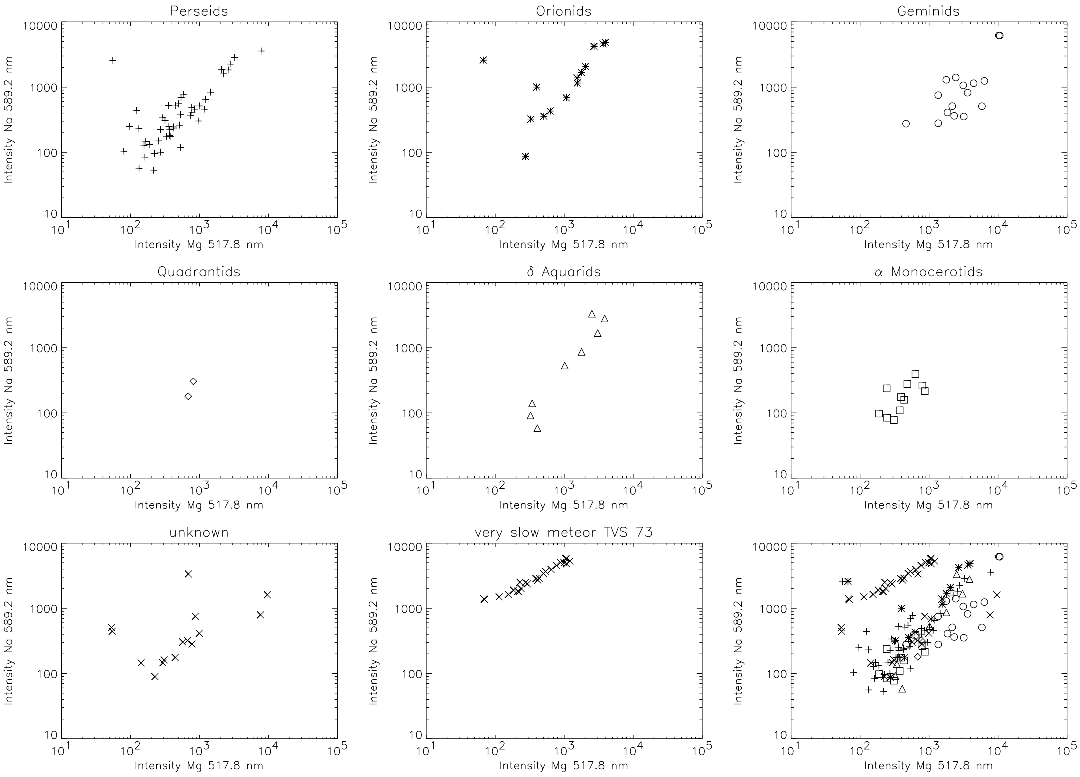

Figure 5: Mg and Na intensities in studied spectra

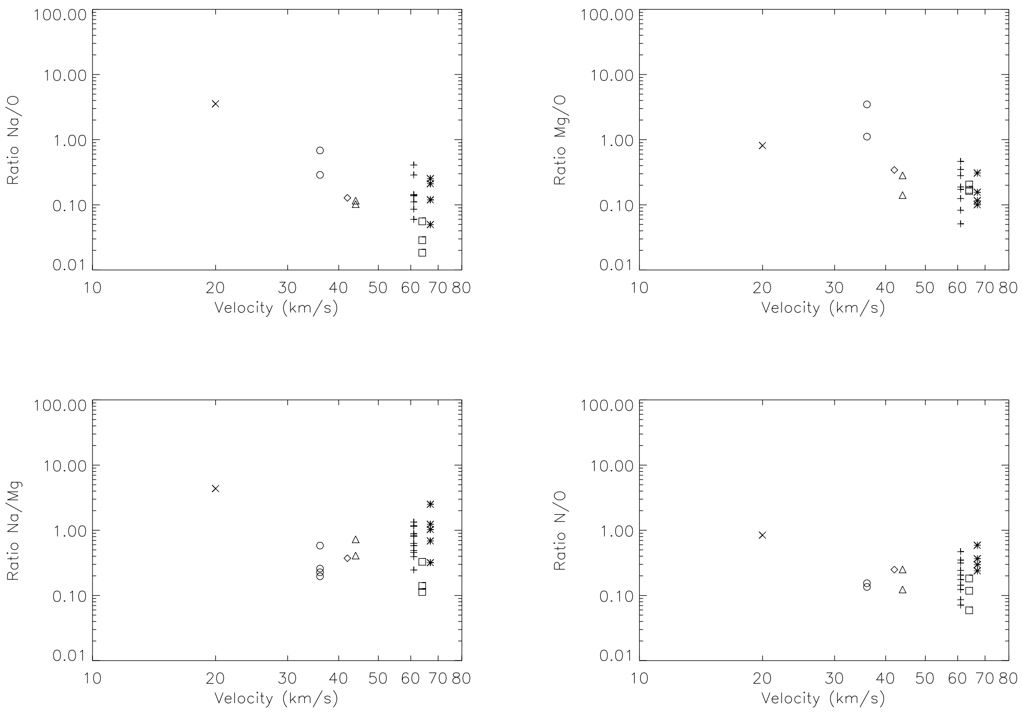

Figure 6: Dependence on velocity — all spectra

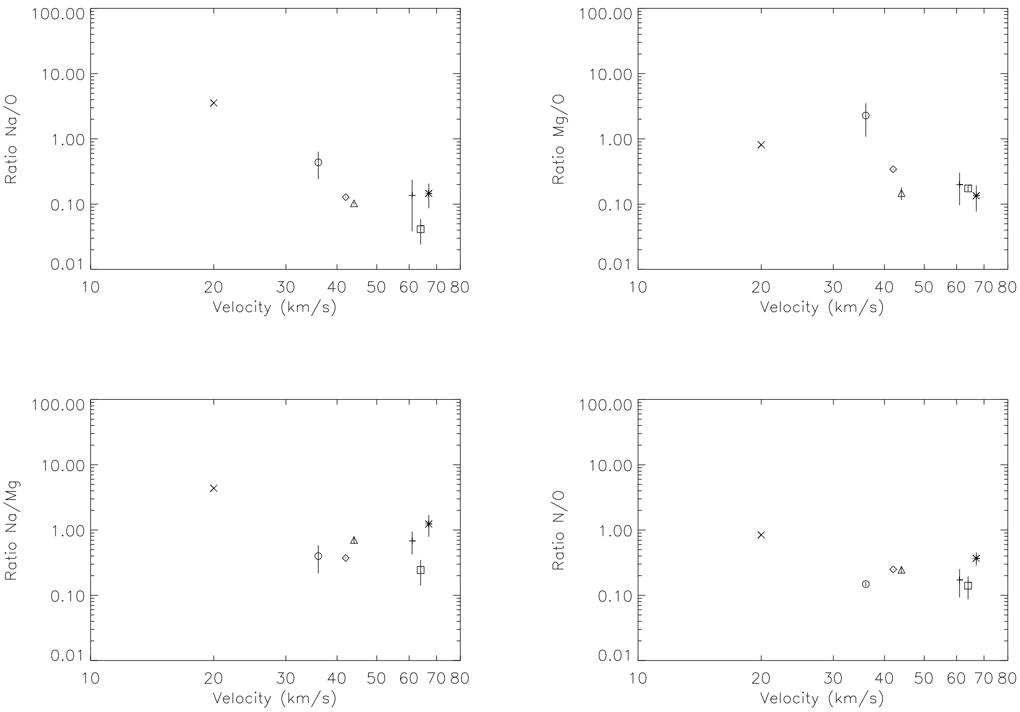

Figure 7: Dependence on velocity — averages

The Figs. 6 and 7 show the similar plots. The weighted[1] averages with standard deviation bars (Fig. 7) are more scientific but don't show how many spectra were averaged and how significant shower value is. Thus I find Fig. 6 to be a better form.

The symbols plotted on Figs. 6 and 7 are the same as the ones on Figs. 4 and 5: asterisk — Orionids (67 km/s), square — α Monocerotids (64 km/s), plus sign — Perseids (61 km/s), triangle — δ Aquarids (44 km/s), diamond — Quadrantids (42 km/s), circle — Geminids (36 km/s) and x — very slow meteor (about 20 km/s).

The Na/O ratio decreases with increasing velocity. All shower are in compliance with this relation except α Monocerotids. The differences of α Monocerotids spectra aren't caused by velocity and indicate differences in meteoroids composition.

The Mg/O plots don't show clear relation. Geminids are known to have bright Mg line. But the TVS 73 point is unsure because both lines are faint and the signal/noise ratio is very bad. In addition, Mg excitation potential phenomenon (see subsection 4.2) probably influence this plot too.

The relation of Na/Mg ratio on the velocity should be divided into two parts. In case of slow meteor Mg line isn't saturated and is optical thin (also see subsection 4.2). In that velocity range Na/Mg ratio decreases with increasing velocity. In the second part both lines are saturated and optical thick. Here Na/Mg ratio slightly increase with increasing velocity. The low amount of sodium in the α Monocerotids spectra is already mentioned.

The ratio N/O should be constant, independent on velocity. It approximately is. The TVS 73 point is uncertain, because N line is very faint in this spectrum and the ratio is very effected by the noise.

6 Peculiar features of α Monocerotids

Jenniskens et al. 1996, 1997 found that α Monocerotids penetrate deeper into the atmosphere than meteoroids of the Orionid stream or Perseid stream (meteoroids with similar velocity) and that their light curves do not show flares. The Jenniskens' results imply that α Monocerotids are more compact than other showers meteoroids and can therefore contain lower amount of volatile elements. (Section 2).

Our spectra show very low abundance of Na in all recorded α Monocerotid spectra (Sections 3 and 5) and the hypothesis concerning low amount of volatile elements could be confirmed, at least for sodium.

Acknowledgement: Two of authors (R. Štork, M. Šolc) acknowledge the support by Grant Agency of the Czech Republic (grant 96/205/0213)

[1] the weight is the intensity of lines — meteor brightness

References

[1] Borovička J. 1993: A fireball spectrum analysis, A&A 279, p. 627–645

[2] Borovička J. 1994: Two components in meteor spectrum, Planet. Space Sci., Vol. 42, No. 2, p. 145–150

[3] Borovička J. and Boček J. 1995: Television spectra of meteors; Earth, Moon, and Planets 71, p. 237–244;

[4] Brown P., Rendtel J., and Molau S. 1996: The outburst of the α Monocerotid meteors on 22^{nd} November 1995, ACM 96, Versailles

[5] Jenniskens P., Betlem H., de Lignie M., and Langbroek M. 1997: The detection of a dust trail in the orbit of an Earth–threatening long–period comet, ApJ 479, p. 441–447;

[6] Štork R. 1998: Optical and infrared observations of solid state interplanetary matter, PhD Thesis, Charles University Prague