Meteors in the near-infrared

Damir Šegon[1,5], Željko Andreić[2], Denis Vida[3,4], Filip Novoselnik[3,4], and Korado Korlević[5]

[1] **Astronomical Society ”Istra” Pula, Park Monte Zaro 2, HR-52100 Pula, Croatia**
`damir.segon@pu.htnet.hr`

[2] **University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, Pierottijeva 6, HR-10000 Zagreb, Croatia**
`zandreic@rgn.hr`

[3] **Astronomical Society Anonymus, B. Radica 34, HR-31550 Valpovo, Croatia**
`denis.vida@gmail.com` and `novoselnikf@gmail.com`

[4] **Faculty of Electrical Engineering, University of Osijek, Kneza Trpimira 2B, HR-31000 Osijek, Croatia**

[5] **Višnjan Science and Education Center, Istarska 5, HR-51463 Višnjan, Croatia**
`korado@astro.hr`

Experimental simultaneous video observations were performed by the Croatian Meteor Network in 2009 and 2012 with four cameras in different visual and near-infrared parts of the meteor spectra. These showed that significant parts of the meteor radiation in the near-infrared can be observed by 1004X video cameras. Different light curves were observed in the near-infrared as well as in the visual part of the meteor spectra, without any obvious physical definitions describing these differences. The influence of this additional light collected by video cameras seems to be the main source of the discrepancy between visual and video magnitude estimates, with important consequences for video meteor analysis in its whole.

1 Introduction

Different authors with varying equipment (Borovička, 1999; Jenniskens et al., 2002) showed that meteors are radiating at wavelengths of the spectra invisible to the human eye. This can be seen in the cases of spectra obtained by high-precision spectroscopes (Jenniskens, 2004)[1], as well as (Borovička et al., 2005). The first experimental observations in visual and near-infrared (NIR) wavelengths were made from the Observatory of the Astronomical Society “Istra” in Pula during the 2006 Perseids. The results during the maximum proved that meteors can be observed in NIR as well as in the visual part of the spectrum, which led to the establishment of the Croatian Meteor Network (Andreić and Šegon, 2010). During the 2009 and 2012 Perseid maxima, the Croatian Meteor Network set up an installation of four cameras in order to observe meteors simultaneously in different spectral bands, using various filters which are easily available on the market.

2 Basic set-up

The CMN uses 1004X cameras as main observational instrument, which has a declared sensitivity of 0.003 lux at $f/1.2$. The cameras spectral response is shown in Figure 1. As can be seen from the curve, this camera is sensitive up to almost 1 μm—a decent estimate is that in case of a hypothetical continuous spectra, 45% of the total light collected would belong to the NIR part. If we look at typical meteor spectra as presented by Borovička et al. (2005, Figure 3 and Table 1), we can see that there are few very intense atmospheric O and N lines in that part (at 777 nm), which a 1004X camera should be able to capture.

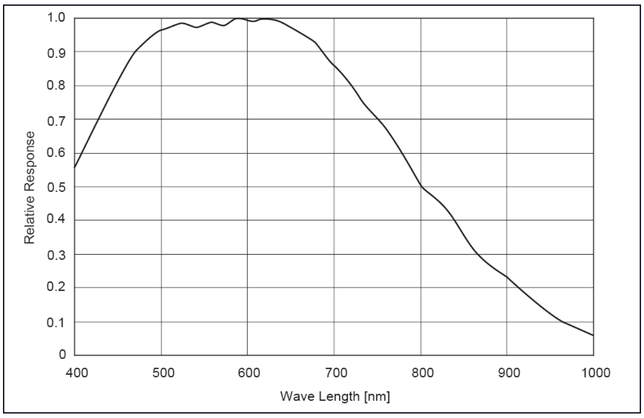

Figure 1 – Spectral response of the 1004X camera.

In order to compare the amount of light collected in the visual and NIR part of the spectrum, we used the following basic set-up. Four video cameras with a fixed gain adjusted to the maximum were equipped with the same 3.8–9 mm $f/0.95$ lenses, mechanically adjusted to point to the same direction and having the same field-of-view size. Four video streamings were than used as inputs to an AVC714 multiplexer (basically a device which joins four videos in a quad one), which allowed us to have simultaneous observations from all four cameras. The

---

[1] `http://www.eso.org/public/archives/images/screen/eso0424c.jpg`, `http://www.eso.org/public/news/eso0424/`.

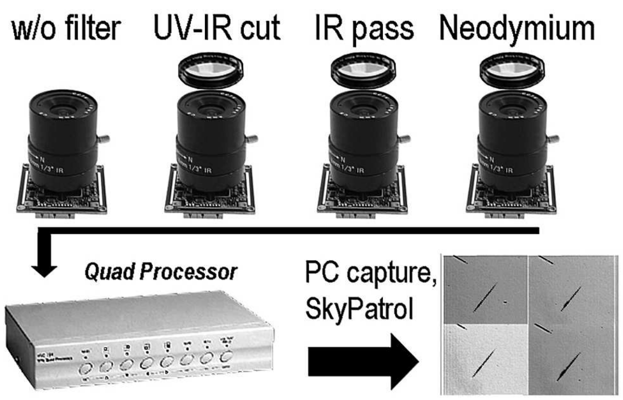

Figure 2 – Basic camera and filter set-up.

cameras were not externally synchronized, so the maximal temporary difference between two videos could be in the order of 1/50 s. It is important to know that the AVC714 multiplexer video output does not have a quite fair image quality compared to the ordinary single video. A single video output stream from the AVC714 multiplexer has then been used as an input video stream to a PC running Mark Vornhusen's SkyPatrol software. A schematic overview of the basic set-up can be seen in Figure 2.

During the 2009 observations, a Philips chipset-based PCI capture card has been used as the capture device, with a maximal resolution of 704 × 576 pixels. The first camera has been used without any filters, the second one was equipped with a UV-IR block filter in order to observe only the visual part of the meteor spectrum, while the third one has been equipped with a 680 nm IR pass filter in order to capture only the NIR part. The spectral characteristics of the UV-IR block and IR pass filters can be seen in Figures 3 and 4, respectively.

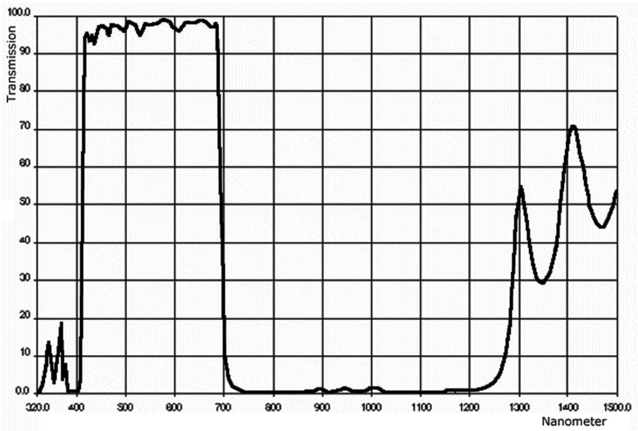

Figure 3 – Spectral characteristics of the UV-IR block filter.

During the 2012 observations an EasyCap USB capture device has been used, allowing a maximal resolution of 720 × 576 pixels. A fourth camera has been equipped with a neodymium (Nd) filter, normally used as a light pollution suppression device in amateur astrophotography. As can be seen from the spectral characteristic of the neodymium filter shown in Figure 5, it filters out the sodium (Na) line (in which yellow sodium street lights emit), which is one of the most prominent lines in the visual part of a meteor spectrum.

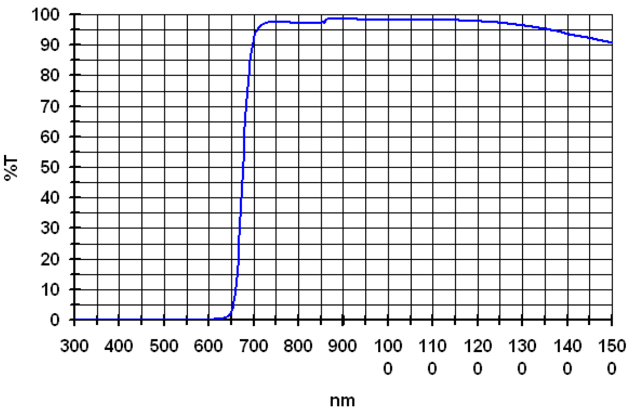

Figure 4 – Spectral characteristics of the IR pass filter.

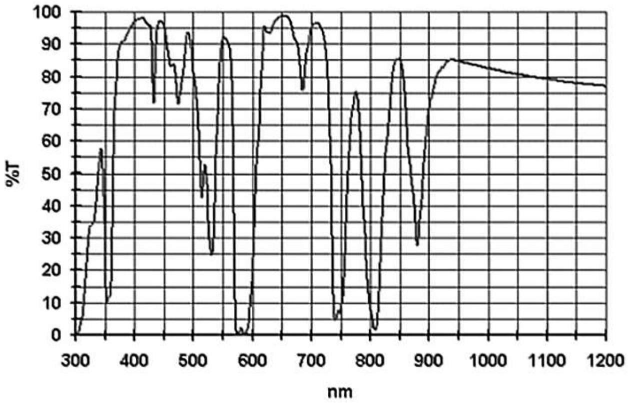

Figure 5 – Spectral characteristics of the neodymium (Nd) filter.

All images were processed by the standard CMN procedure, using Peter Gural's MTP_Detector software, providing the intensity level over the median background for each meteor detection.

3 Results and discussion

A total of more than 50 meteors were captured in 2009 and 2012. The light curves produced from processed images show that, in some cases, there is almost no difference in the shape of light curves obtained by cameras equipped with different filters (Figure 6). In some other cases, however, there is a significant difference in the light curve's shape (Figure 7), suggesting that there are variations in the meteor's spectrum.

Moreover, in almost all cases, results show that meteors radiate significantly in the NIR part of the spectrum, which is in agreement with results obtained by Shigeno and Toda (2008) as well as in previously cited papers. Even more interesting, there are also cases in which the near-infrared part of the radiation does not seem to be significant (Figure 8)—but there are some light curves that are really hard to interpret (Figure 9).

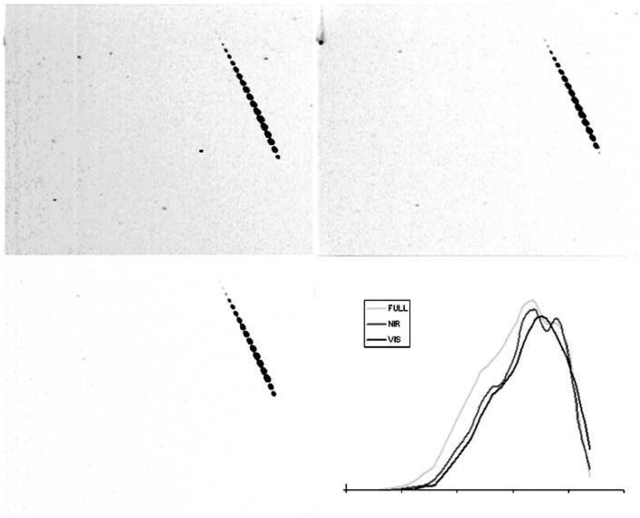

Figure 6 – Light curves of the same meteor through different filters. In this case, there is no significant difference in light curve shape.

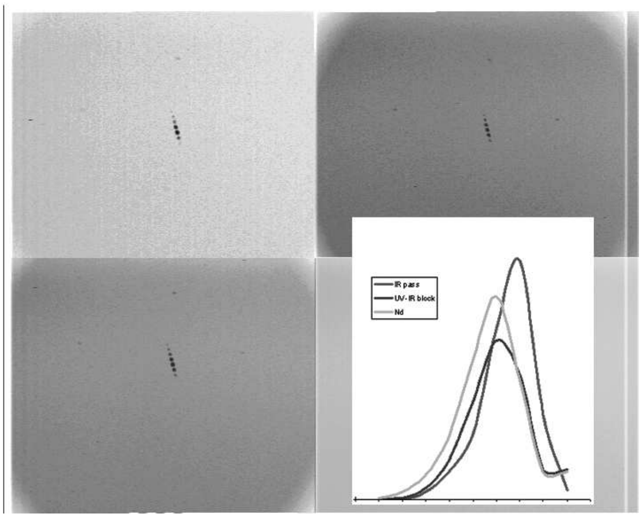

Figure 7 – Light curves of the same meteor through different filters. difference in light curve shape in this case suggests variations in the meteor's spectrum.

It seems that the meteor velocity plays an important role in NIR meteor radiation: swifter meteors show more near-infrared radiation compared to slower ones. This has to be studied in more detail, as this could resolve the currently—to the authors' knowledge—unresolved discrepancy between visual and video meteor magnitudes.

If we take a look at the neodymium filter spectral characteristic, the usage of a neodymium filter opens the door for mass observations of meteors in the Na line, but in an "inverse" way: when comparing intensities obtained by a UV-IR blocking filter and a neodymium filter, we may assume that possible difference are mainly caused by differences in radition in the Na line. In other words, if a meteor looks fainter when captured through a neodymium filter than through a UV-IR blocking filter, this means that we observed the Na line. If the intensities are of about the same level, this means that there was no significant emission in the Na line.

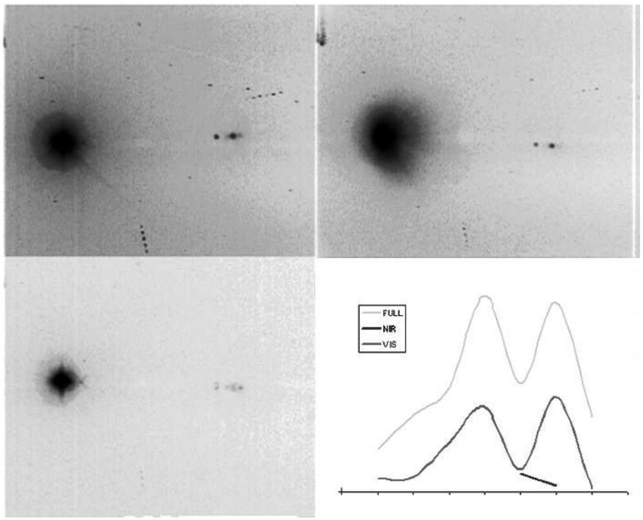

Figure 8 – Light curves of the same meteor through different filters. The radiation in the near-infrared part of the spectrum is of very low intensity

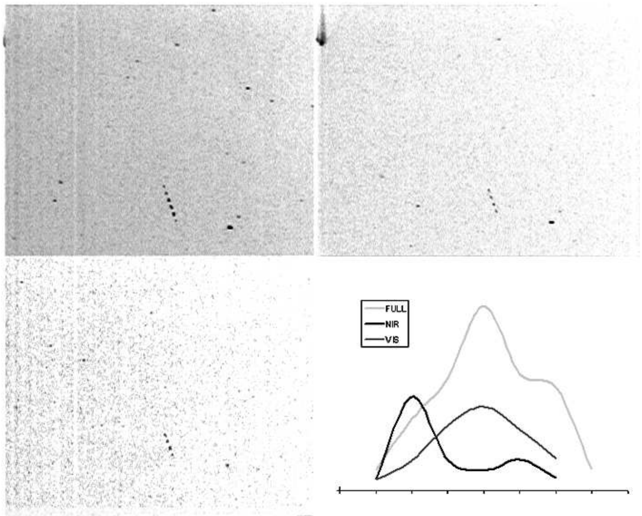

Figure 9 – Light curves of the same meteor through different filters. Significant differences in the light curve shape are sometimes hard to interpret.

4 Conclusions and future work

The standard CMN 1004X video cameras (as well as other video cameras used in meteor work) allow meteor observations at different wavelengths of the meteor spectra. Our experimental set-up has shown that it is possible to do wide-band meteor spectroscopy.

Our next goal will be to set up another four cameras, but based on more reliable technology in order to obtain a more decent observing quality for more serious analysis. There are two topics that could be addressed to begin with:

1. the analysis of the influence of the velocity on the near-infrared part of the meteor radiation; and
2. indirect observations of meteors in the Na line only.

5 Acknowledgements

Our acknowledgments go to all members of the Croatian Meteor Network, which in alphabetical order (first name first) consists of the following persons:

> Alan Pevec, Aleksandar Borojević, Aleksandar Merlak, Alen Žižak, Berislav Bračun, Dalibor Brdarić, Damir Matković, Damir Šegon, Dario Klarić, Dejan Kalebić, Denis Štogl, Denis Vida, Dorian Božićević, Filip Lolić, Filip Novoselnik, Gloryan Grabner, Goran Ljaljić, Ivica Ćiković, Ivica Pletikosa, Janko Mravik, Josip Belas, Korado Korlević, Krunoslav Vardijan, Luka Osokruš, Maja Crnić, Mark Sylvester, Mirjana Malarić, Reiner Stoos, Saša Švagelj, Sonja Janeković, Tomislav Sorić, VSA group 2007, Zvonko Prihoda, Željko Andreić, Željko Arnautović, and Željko Krulić.

Thanks also go to the VSA2012 Video Meteor Group and to Peter Gural for the constructive discussions on meteor shower problems.

This work was partially supported by the Ministry of Science, Education and Sports of the Republic of Croatia, Višnjan Science and Education Center, and by private funds of CMN members.

References

Andreić Z. and Šegon D. (2010). "The first year of Croatian Meteor Network". In Kaniansky S. and Zimnikoval P., editors, *Proceedings of the International Meteor Conference*, Šachtička, Slovakia, September 18–21, 2008, IMO, pages 16–23.

Borovička J. (1999). "Meteoroid properties from meteor spectroscopy". In Baggaley W. J. and Porubčan V., editors, *Proceedings of the International Conference Meteoroids 1998*, Tatranská Lomnica, Slovakia, August 17-21, 1998. Astronomical Institute of the Slovak Academy of Sciences, page 355.

Borovička J., Koten P., Spurný, P., Boček J., and Štork R. (2005). "A survey of meteor spectra and orbits: evidence for three populations of Na-free meteoroids". *Icarus*, **174**, 15–30.

Jenniskens P., Jehin E., Cabanac R. A., Laux C. O., and Boyd I. D. (2004). "Spectroscopic anatomy of a meteor trail cross section with the European Southern Observatory Very Large Telescope". *Meteoritics and Planetary Science*, **39**, 609–616.

Jenniskens P., Tedesco E., Murthy J., Laux C. O., and Price S. (2002). "Spaceborne ultraviolet 251-384 nm spectroscopy of a meteor during the 1997 Leonid shower". *Meteoritics and Planetary Science*, **37**, 1071–1078.

Shigeno Y. and Toda M. (2008). "Comparison of TV magnitudes and visual magnitudes of meteors". *WGN, Journal of the IMO*, **36**, 79–82.