DEVELOPMENT OF AUTOMATED HIGH-RESOLUTION SLOW-SCAN CCD SYSTEMS FOR METEOR SPECTROSCOPY: PRELIMINARY RESULTS. J.M. Rey[1] and J.M. Madiedo[1,2]. [1]Facultad de Ciencias Experimentales, Universidad de Huelva, Huelva, Spain, madiedo@uhu.es, [2]Dpto. De Física Atómica, Molecular y Nuclear, Facultad de Física, Universidad de Sevilla, 41012 Sevilla, Spain.

Introduction: Meteor spectroscopy provides valuable data about the composition of meteoroids striking the atmosphere [1, 2, 3]. The results obtained from the analysis of meteor spectra can also be used to infer information about the chemical nature of the parent bodies of these particles of interplanetary matter. With this aim, we have employed since 2006 high-sensitivity CCD video cameras with attached holographic diffraction gratings (500-1000 lines/mm) to record the emission spectra produced during the ablation of meteoroids in the atmosphere [4, 5]. These devices allow for a precise recording of the evolution of the intensity of emission lines with time and, for multi-station events, with height also [6]. During August 2012 we made an additional effort in the framework of this continuous spectroscopic campaign by setting up two new automated spectrographs, although these are based on slow-scan high-resolution CCD devices. These new systems are described here and the first results obtained so far are presented.

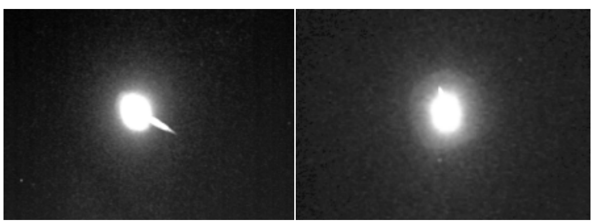

Figure 1. Composite image of the bolide analyzed here, as imaged from Sevilla (left) and El Arenosillo (right).

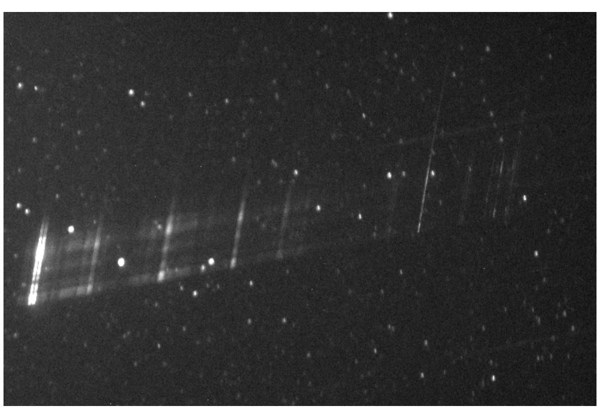

Figure 2. Emission spectrum registered by the slow-scan CCD spectrograph.

The slow-scan CCD spectrographs: Our new high-resolution spectral system consists of two slow-scan high-sensitivity CCD devices (models ATIK 4000LE and ATIK 16HR) that employ 1000 lines/mm diffraction gratings attached the objective lenses. They operate since August 2012 from our meteor observing station located in Sevilla, where an array of high-sensitivity CCD video cameras is also used for the continuous monitoring of meteor and fireball activity. The new spectrographs generate imagery in FITS files which are sent to GPS synchronized computers. The exposition time is adjusted according to the conditions of the sky. These systems are currently covering an extension of about 50ºx50º degrees in the night sky. They provide a resolution of about 5 nm/pixel. Dead times between images is one disadvantage with respect to the operation of our video spectrographs, that can work continuously during the whole night. The slow-scan CCD spectrographs work in a fully autonomous way by means of software developed by us. Thus, the devices are automatically started after the evening twilight and switched off just before the morning twilight. When the CCD video devices working from the same meteor station detect a bright event, our software takes the corresponding FITS images from the hard disk of the computers that control the slow-scan CCD spectrographs and sends them to our FTP server. These images are then inspected by an operator in order to check if they contain the emission spectrum produced by fireballs registered by our video cameras. On the other hand, we have also developed a software (CHIMET) to analyze the emission spectra recorded by our spectrographs.

Radiant data			
	Observed	Geocentric	Heliocentric
R.A. (º)	45.3±0.2	59.2±0.2	
Dec. (º)	58.6±0.1	41.6±0.1	
V_∞ (km/s)	60.4±0.3	59.2±0.3	41.7±0.3
Orbital parameters			
a (AU)	63.9±5.1	**ω (º)**	155.8±0.5
e	0.98±0.03	**Ω (º)**	140.5395 ± 10^{-4}
q (AU)	0.969±0.01	**i (º)**	112.0±0.2

Table 1. Radiant and orbital data (J2000).

Preliminary results and discussion: On August 13, 2012, at 1h23m33.4±0.1s UTC, a mag. -9 Perseid fireball was simultaneously registered by high-sensitivity CCD video devices operating from two SPMN stations: Sevilla and El Arenosillo (Figure 1). Besides, its emission spectrum was also recorded from

Sevilla by one of our new high-resolution slow-scan CCD spectrographs (Figure 2). The atmospheric trajectory and radiant were calculated with our AMALTHEA software. From this analysis it follows that the bolide began at 97.5±0.5 km above the ground level, with the terminal point located at a height of 76.4±0.5 km. The preatmospheric velocity was 60.4±0.3 km/s. With this information, the orbit of the parent meteoroid was calculated. Radiant and orbital data are summarized in Table I.

From the image shown in Figure 2 we obtained initially the emission spectrum as an intensity profile (pixel brightness, in arbitrary units, vs. pixel number). The signal was then converted to intensity versus wavelength by identifying typical lines appearing in meteor spectra. In this case, prominent lines produced by chemical species such as Mg, Ca and Na were also very helpful to accomplish this calibration. Then, the spectrum was corrected by taking into consideration the spectral response of the instrument. The result is shown in Figure 3. Although most lines correspond to Fe I multiplets, the most prominent features in the spectrum are the H and K lines of ionized calcium, which appear perfectly discerned as a result of the higher resolution of the spectrograph. Multiplet Ca I-2 (422.7 nm) was also identified. Other two important lines are due to multiplets Na I-1 (588.9 nm) and Mg I-2 (516.7 nm). The contribution of Mg I-3 (382.9 nm) is also seen, together with lines from Ni I (361.9 nm), Cr I (357.8 nm) and Ba II (413.0 nm). The contributions from atmospheric N_2 and O I are also seen.

Conclusions: We have setup an automated meteor spectrograph based on a low-scan CCD high-resolution device. This significantly increases the resolution of the emission spectra we are obtaining with our previous high-sensitivity CCD video devices. This system, which is controlled by means of a dedicated software, has been employed to obtain the emission spectrum of the Perseid fireball analyzed here.

Acknowledgements: We acknowledge support from the Spanish Ministry of Science and Innovation (project AYA2009-13227).

References: [1] J.M. Trigo-Rodríguez et al. (2003) *MAPS* 38, 1283-1294. [2] Trigo-Rodríguez et al. (2004) *MNRAS* 348, 802-810. [3] Borovicka, J. (1993) *Astron. Astrophys*. 279, 627-645. [4] Madiedo J.M. and Trigo-Rodríguez J.M. (2007) *EMP* 102, 133-139. [5] Madiedo J.M. et al. (2010) *Adv.in Astron*, 2010, 1-5. [6] Madiedo J.M. et al. (2012) MNRAS, submitted.

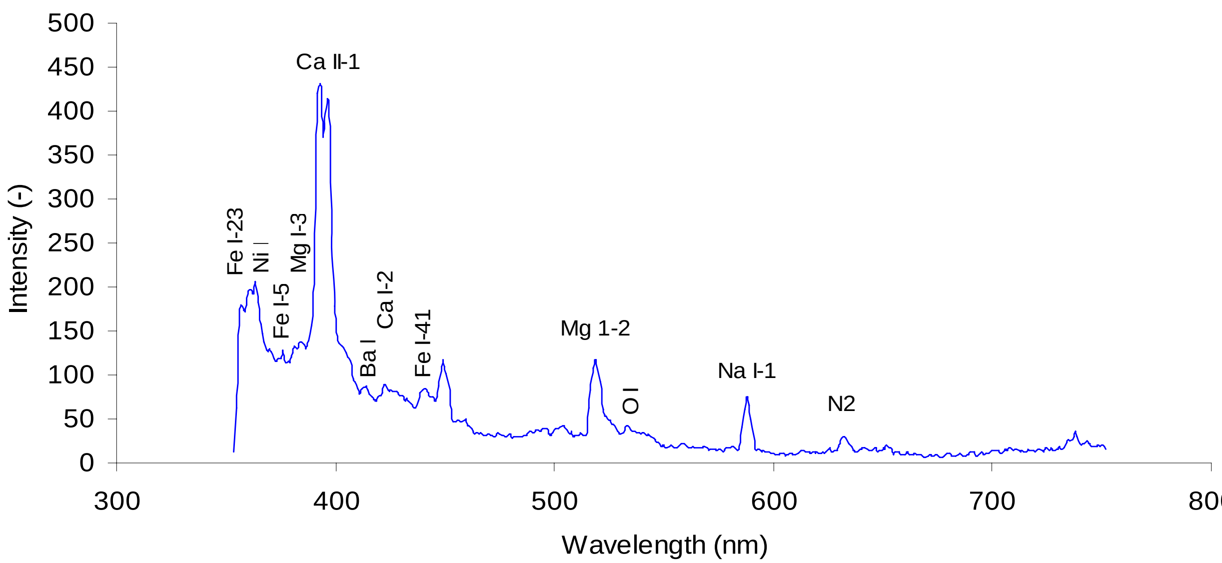

Figure 3. Main lines identified in the calibrated emission spectrum.