INFRARED OBSERVATIONS OF COMET C/2012 S1 (ISON).

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Introduction: Comet C/2012 S1 (ISON) provided an excellent opportunity to study a comet arriving from the Oort cloud for the very first time. With the possibility of surviving a sungrazing trajectory that would potentially provide important post-perihelion data after the removal of a substantial amount of surface material, ISON became a prime target for an extended campaign by many observers.

With a brightness that was far below many original estimates, and the lack of post-perihelion survival, there was only a narrow window of opportunity to obtain infrared spectroscopic observations. Here we present the results of near- and mid-infrared spectroscopy of comet ISON.

Observations: Comet C/2012 S1 (ISON) was observed on September 11 and October 19, 2013 (UT) , with the Prism disperser of the SpeX spectrograph on NASA's Infrared Telescope Facility. On the former date a 3.0 arcsec slit was used, providing low spectral resolution (R~25) data on the scattered light of the dust between 0.8-2.4 microns. On the latter date, a 3.0 arcsec slit and a 0.8 arcsec slit were used (the latter providing proportionately higher resolution).

On November 11 and 12, 2013 (UT) ISON was observed using The Aerospace Corporation's Broad-band Array Spectrograph System (BASS) providing 3-13 micron spectra with R~30-120, using a circular aperture 4.4 arcsec in diameter.

Data Reductions: The SpeX observations were corrected for telluric absorption features and flux-calibrated using the A0V stars HD 79108 (Sept. 11) and HD 88960 (Oct. 19). The BASS observations were calibrated using Sirius.

Scattered-Light Spectra: Figure 1 shows the SpeX data obtained in September and October. For all three spectra, the scattered light was slightly redder than the incident solar spectrum, being approximately equal to the solar spectrum times $\lambda^{0.3}$ where λ is the wavelength of the light. This wavelength dependence was the same on both dates, and was independent of the slit width.

Thermal Emission: The bulk of the BASS spectra were dominated by the thermal emission of the dust. At these wavelengths, the comet was brighter on the second night than the first, suggesting that the brightening reported world-wide by citizen scientists was already under way. The BASS spectra were scaled to the same level and merged to produce a spectrum of higher signal/noise than each individual one (no significant difference was seen in the spectral shape or structure on the two nights). The merged spectrum is show in Figure 2.

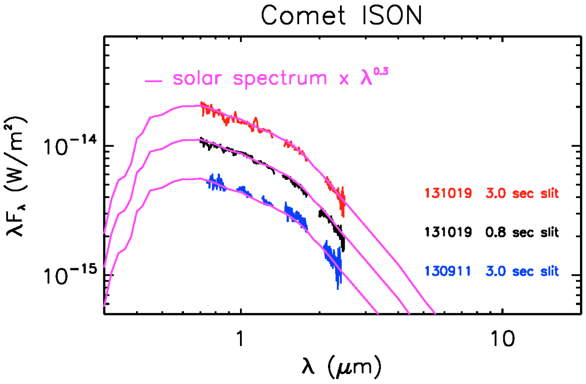

Fig. 1 – The SpeX spectra of ISON. All were consistent with a solar spectrum (here shown smoothed) x $\lambda^{0.3}$, independent of date and slit width.

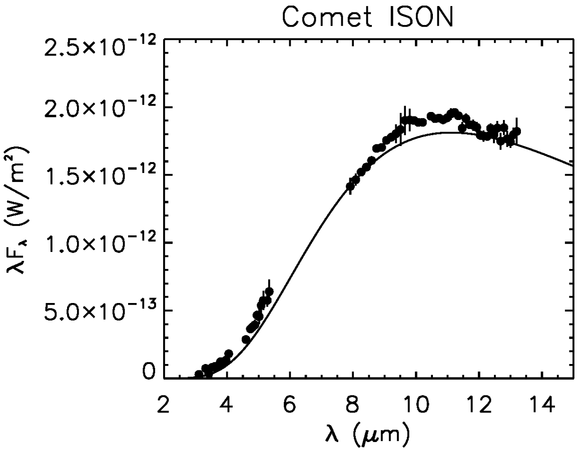

Fig. 2 – The merged BASS spectrm from November 11 & 12. Also shown is a blackbody spectrum with T=330 K.

The 11.3 micron feature of crystalline Mg-rich olivine was present in the spectrum. The strength of the overall silicate band was 10% or less above the underlying continuum. Such a strength is not uncommon among many comets that are dynamically new or that have very long periods [1,2].

Due to a number of time constraints, absolutely calibrated flux observations of the scattered light were not obtained on the nights where BASS observation were made. However, at the shortest BASS wavelengths the data are significantly above that expected from thermal emission alone, and if this excess flux is due to the addition of the scattered light, the excess would be consistent with the scattered light seen on the SpeX observations scaled to a level that would produce a bolometric albedo (scattered light divided by scattered+thermal light) of ~0.15. This is typical of a number of comets measured at similar scattering phase angles (~ 70 deg.) [3].

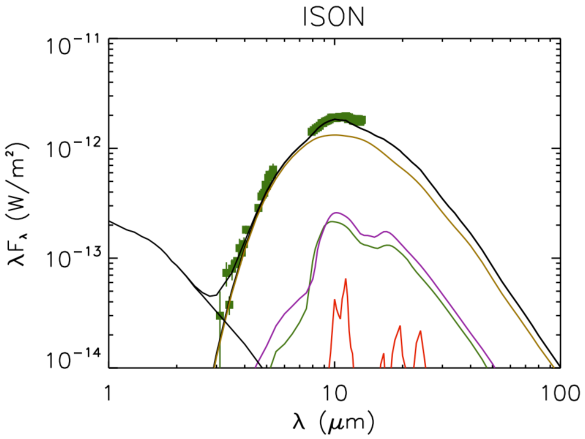

Fig. 3 – A simple model for the BASS data on ISON. The mineral components include amorphous carbon (upper smooth brown curve), amorphous olivine and pyroxene (two middle curves) and crystalline olivine (lowermost colored curve). The sum is the black curve, which requires a small component of scattered light (black curve to the left), in order to fit the shortest wavelength high-quality data.

References: [1] Sitko, M.L., et al. (2004), *ApJ, 612,* 576. [2] Kolokolova, L., et al. (2004), *A&A, 463,* 1189. [3] Kolokolova, L., et al. (2004), *Comets II*, 577-604.

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