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Was a Long-Lived, High Velocity Gas Jet Produced by the Comet Tempel 1 Deep Impact Event: Evidence from High Spectral Resolution [OI] 630 nm Interference Spectra

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Introduction: We report on results from high spectral resolution (R > 100,000) observations of comet P/Tempel 1 taken over a 1' FOV before and after the Deep Impact event. These spectra were obtained with an all-reflective spatial heterodyne spectrometer (SHS) coupled to the National Solar Observatory McMath-Pierce main telescope. We acquired several spectra centered from Tempel 1 during the period of 07/04/2007-07/06/2007 UT. We report on the presence and evolution of an emission feature that appears in the post impact narrow-band spectra centered near the telluric OI 630 nm air glow line. The unidentified feature is Doppler shifted relative both the telluric and comet rest velocities and the extent of this shift appears to change in its velocity offset over time in a manner consistent with changes in the projected Earth-Impact site vector from the comet.

Observational Details and Technique: Our SHS instrument is physically similar to a Sagnac style interferometer, where input light is split into two beams that travel in opposite directions through the optical system and are then recombined. In the SHS, the beam is split by a grating and the optics aligned such that the wavefronts of the two beams are parallel at the output for only one wavelength. The dispersive property of the grating alters the trajectories of all other wavelengths so that they exit the instrument with their wavefronts crossed. This results in a 2-D linear interference pattern at the output with fringe frequencies determined by the wavelength separation of each input spectral component from that of the tune. A Fourier transform of the pattern produces a spectrum of the power signature at each wavelength in the sampled bandpass.

With this instrument we obtained several spectra of comet Tempel 1 each night, along with comparison spectra from Jupiter, the Ring Nebula, and the day, dusk, and night skies. Wavelength scale calibration was maintained trough periodic measurements of Rubidium and Thorium-Argon lamp spectra taken on each night.

Our targeting/guide system consisted of a 'hot' mirror which 'picked-off' out of band light from the comet and redirected it to a guiding camera. This system provided unambiguous targeting down to 12th magnitude objects in under clear skies.

Results: In each of the multiple spectra obtained on Tempel 1 after impact we detect a narrow, unresolved emission line that is blue shifted from both the telluric and comet rest wavelengths of the OI 630 nm line. Immediately post-impact we observed emission offset from the comet's geocentric velocity OI emission by 13 km/sec. This observed velocity then changes to 6 km/sec (still blue shifted relative to the geocentric velocity) on the following night, July 06 2005 UT. The feature appears in no other spectra obtained during our run.

Other spectra obtained each night from the sky and several targets include multiple atmospheric absorption and emission lines that, along with test spectra from our calibration lamps were used to unambiguously determine the wavelength scale of the instrument. The precision of this scale corresponds to a substantially smaller Doppler shift than that observed in for the comet Tempel 1 data post-impact emission feature.

The evolution in the Doppler shift of the observed feature is consistent with our tracking a change in the projected vector from the Tempel 1 impact site toward the Earth as the comet rotates. If the feature is cometary OI emission, it would therefore be consistent with the expected behavior of a persistent high-velocity gas jet produced from the impact site.

References:

Belton et al,, *Deep impact : Working properties for the target nucleus - comet 9P/tempel 1*

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