INVESTIGATING ULTRAVIOLET EXCITATION PROCESSES IN 67P/CHURYUMOV-GERASIMENKO. Eric R. Schindhelm[1], Michael F. A'Hearn[2], Jean-Loup Bertaux[3], Lori M. Feaga[2], Paul D. Feldman[4], Joel Wm. Parker[1], Andrew J. Steffl[1], S. Alan Stern[1], Harold A. Weaver[5], [1]*Southwest Research Institute, Department of Space Studies, Boulder, CO*, [2]*Department of Astronomy, University of Maryland, College Park, MD*, [3]*University of Versailles Saint-Quentin en Yvelines, Versailles, France*, [4]*Johns Hopkins University, Department of Physics and Astronomy, Baltimore, MD*, [5]*Johns Hopkins University Applied Physics Laboratory, Laurel, MD*

Introduction: We report analysis of far-ultraviolet (FUV) spectra of the coma of 67P/Churyumov-Gerasimenko taken by the Alice imaging spectrograph onboard the *Rosetta* spacecraft. Alice is comprised of an off-axis paraboloid telescope followed by a Rowland mount spectrograph feeding a double delay line microchannel plate detector [1]. Its large field of view and moderate spectral resolution are ideal for sensitive detection of FUV atomic and molecular emission from the coma. The slit is 5.5° in length with a 0.1° wide top and bottom and 0.05° narrow center. Unlike typical cometary FUV spectra, the emissions observed from 67P appear so far (heliocentric distances >2.5 AU) to be dominated by electron impact excitation from photoelectrons produced by the photoionization of H_2O. We present the evidence for this conclusion and compare the relative strengths of the collisional excitation mechanism to the traditionally observed resonant scattering.

Observations: In November 2014 through January 2015 Alice performed a series of observation campaigns from near-terminator orbits. The radial distances to the comet in these orbits varied between approximately 10 km and 30 km. The pointing profiles were stares above the sub-solar limb, scans across the sub-solar limb, and nadir stares. These observations generally sampled full rotations of the comet (~12.4 hours), allowing us to characterize the variation of the coma from all points around the surface. During the nadir stares it was possible to measure emission from the sunlit species above the nucleus, free of contamination from the interplanetary medium.

Discussion: The coma spectra mostly consist of H I and O I emission lines, species resulting mainly from the dissociation of H_2O, CO, and CO_2. An example spectrum and pointing is shown in Figure 1. In this spectrum the sunlit nucleus is apparent in the bottom of the slit by reflected solar C II 1335 Angstrom emission and rising flux at long wavelengths, while coma gas emission appears throughout the slit. The gas emission shows diurnal variation that can fluctuate by up to an order of magnitude, peaking when the high activity areas are in view.

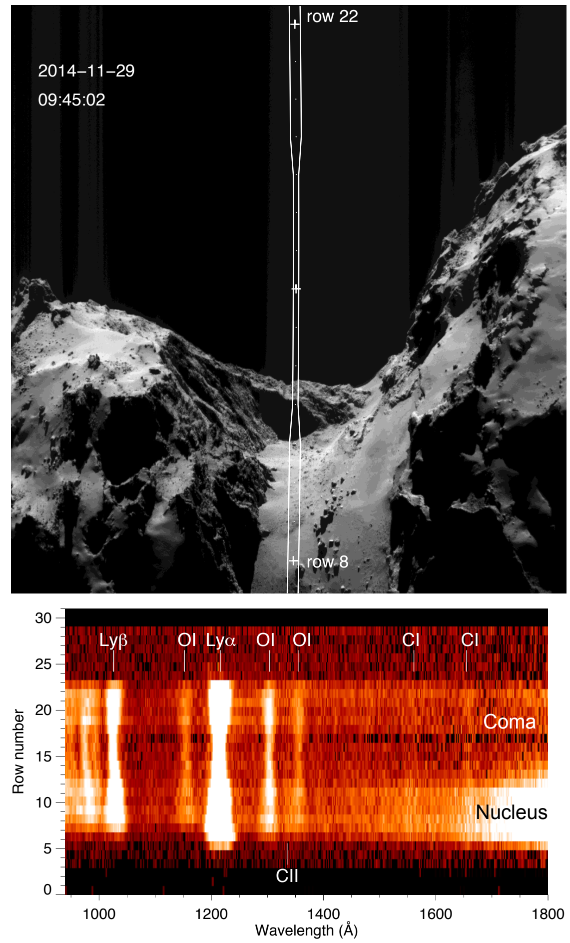

Figure 1: (Top) NAVCAM image taken on November 29th, contemporaneously with a typical Alice observation. The bottom of the Alice slit for these observations lies atop the sunlit nucleus, while the top of the slit is placed over the coma. The observed emission is shown (Bottom) in an Alice 2D spectral image. Reflected sunlight appears in the bottom rows corresponding to the nucleus. O I λλ1152 and 1356 Angstrom emission is indicative of electron impact dissociation of H_2O. Faint C I λλ1561 and 1657 Angstrom emission also appears in the coma.

There is significant OI emission at λλ1152 and 1356 Angstroms, which cannot result from the OI resonant scattering of solar far-ultraviolet photons. The forbidden O I λ1356 multiplet is indicative of excitation due to electron impact by electrons produced by the photoionization of H_2O [2]. The relative intensities are roughly consistent with 200 eV laboratory electron impact spectra [3]. These emissions are unlikely to result from photo-dissociation of H_2O into excited atomic states, based on solar rate [4] and H_2O absorption selection rules that favor the formation of O I in singlet states rather than triplets (1304 Å) or quintets (1356 Å) [5].

Additional support of the H_2O photoelectron excitation mechanism comes from nadir observations, where HI emission above the night side of the nucleus can be observed without contamination of interplanetary HI emission. In these spectra, the ratio of Lyman-α to Lyman-β is also consistent with photoelectron impact of H_2O, but not resonant scattering of the solar FUV lines.

FUV spectra of cometary coma previously measured from Earth are typically dominated by resonant scattering. It is likely that the differences with the Rosetta Alice spectra are related to the very different spatial scales sampled: the Alice spectra sample the innermost coma (heavily weighting points within 30 km of the nucleus) whereas most Earth based observations are primarily sampling the coma at thousands to tens of thousands of kilometers from the nucleus. Since the photoelectron density is highest near the nucleus, collisional excitation should be relatively more important for the Rosetta observations.

C I λλ1561 and 1657 and C II λ1335 emission also appear in these spectra, and their relative strength implies electron impact excitation of either CO_2 or CO. The relative intensities of 1657:1561:1335 are approximately 2:1:1, which more likely results from CO_2 dissociation [6, 7, 8]. Combined with cross sections of 100 eV electrons, the ratio of C I λ1657 to Lyman-β can be used as a proxy for the CO_2/H_2O ratio. The R-Alice data suggest this ratio varies from a few percent to ~10 percent, consistent with direct measurements of the CO_2/H_2O ratio made at infrared wavelengths by the VIRTIS imaging spectrograph [9] onboard *Rosetta*.

We will present additional results of the coma evolution, CO_2/H_2O ratio, and spatial distribution as the comet continues towards the sun and other regions of the nucleus become illuminated.

References:

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