EPSC Abstracts
Vol. 10, EPSC2015-727, 2015
European Planetary Science Congress 2015

Far-ultraviolet spectroscopy from inside the coma of comet 67P/Churyumov-Gerasimenko with Alice on Rosetta

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Abstract

We present observations of the coma of comet 67P/Churyumov-Gerasimenko made by the *Alice* far-ultraviolet spectrograph on *Rosetta* between January and mid-April 2015. Atomic emissions of hydrogen, oxygen, and carbon are interpreted in terms of dissociative electron excitation of H_2O, CO_2, CO, and O_2, whose relative abundances can be derived from the spectra and which are found to be both spatially and temporally variable.

1. Introduction

The *Alice* far-ultraviolet spectrograph is a lightweight, low-power, imaging spectrograph optimized for *in situ* far-ultraviolet (FUV) spectroscopy of comet 67P. It is designed to obtain spatially-resolved spectra in the 700-2050 Å spectral band with a spectral resolution between 8 and 12 Å for extended sources that fill its field-of-view. The slit is in the shape of a dog bone, 5.5° long, with a width of 0.05° in the central 2.0°, while the ends are 0.10° wide. Each spatial pixel or row along the slit is 0.30° long. Details of the instrument are given in [2]. Measurements of the ultraviolet reflectance properties of the nucleus have been reported in [3].

In our initial paper on the measurement of coma gas emissions [1], we reported on observations made between August and November 2014 that showed multiplets of atomic hydrogen and oxygen concentrated in the first few km above the limb of the comet. From the relative intensities and the presence of the forbidden O I λ1356 multiplet, we identified photoelectron dissociative excitation of H_2O as the source of the observed atomic emissions. The electrons are produced by the photoionization of H_2O. This spectrum is fundamentally different from far-ultraviolet comet spectra observed from Earth orbit, which view the coma on scales of hundreds to thousands of km, in which atomic emissions are due to resonance fluorescence of solar ultraviolet radiation. The spectra also showed weak emission of C I $\lambda\lambda$1561 and 1657 and C II λ1335, which we attributed to electron dissociative excitation of CO_2, whose abundance relative to H_2O was found to be variable.

2. Results and Summary

Beginning in January 2015 we have observed many instances in which the atomic multiplet ratios have differed significantly from those nominally seen and attributed to electron dissociative excitation of H_2O. These were observed in two distinct modes: 1) at distances greater than 80 km from the comet, coma is observed in the wide ends of the spectrograph slit above both sunward and anti-sunward limbs; and 2) in instances when part of the nucleus is in shadow so that emissions are seen along the illuminated line-of-sight to the dark nucleus. The relative atomic line intensities can be used, together with laboratory cross section data, to evaluate the contributions of the various molecular parents to the observed spectra. For example, when C I λ1657 is comparable to H I Lyman-β in brightness this implies a high CO_2 abundance relative to H_2O. Another interesting case is when the brightness of O I λ1356 is comparable to that of O I λ1304 but C I λ1657 is weak, which implies electron impact on O_2 as an important source. The origin of the significant abundance of O_2 near the nucleus remains uncertain.

In addition to the spectral analysis and the relative parent abundance determination, we will discuss the evolution of the coma emissions with time, their spatial extent, and their possible sources relative to the locations on the nucleus near where they are seen. Quantitative analyses will require concurrent information from several other *Rosetta* instruments.

Acknowledgements

Rosetta is an ESA mission with contributions from its member states and NASA. We thank the members of the *Rosetta* Science Ground System and Mission Operations Center teams, in particular Richard Moissl and Michael Küppers, for their expert and dedicated help in planning and executing the *Alice* observations. The *Alice* team acknowledges continuing support from NASA's Jet Propulsion Laboratory through contract 1336850 to the Southwest Research Institute. The work at Johns Hopkins University was supported by a subcontract from Southwest Research Institute.

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