EPSC Abstracts
Vol. 10, EPSC2015-386, 2015
European Planetary Science Congress 2015

Sub-Surface Properties of Comet 67P/Churyumov-Gerasimenko Derived from Combined Thermal and Spectroscopic Data from the MIRO Instrument

P. von Allmen (1,2), S. Lee (1), N. Biver (3), S. Gulkis (1), D. Bockelee-Morvan (3), M. Hofstadter (1), F.P. Schloerb (6), M. Choukroun (1), S. Keihm (1), L. Rezac (4), C. Leyrat (3), E. Lellouch (3), P. Hartogh (4), J. Crovisier (3), M. Janssen (1), C. Jarchow (4), P. Encrenaz (3), T. Encrenaz (3), W. Ip (5), T. Spilker (7), M. Allen (1), G. Beaudin (3), and M. Frerking (1)

(1) Jet Propulsion Laboratory/California Institute of Technology, California, USA (2) pva@jpl.nasa.gov (3) Observatory of Paris, Meudon, France (4) Max Planck Institute, Gottingen, Germany (5) Institute of Astronomy and Space Science, Jhongli, Taiwan (6) University of Massachusetts, Massachusetts, USA (7) Solar System Science and Exploration, California, USA

Abstract

The Microwave Instrument on the Rosetta Orbiter (MIRO) [1] measures a) thermal emission from the nucleus of comet 67P/Churyumov-Gerasimenko in two continuum bands (centered near 190 GHz and 562 GHz), and b) eight molecular emission and absorption lines (of $H_2{}^{16}O$, $H_2{}^{17}O$, $H_2{}^{18}O$, CH_3OH, NH_3, and CO) in the 562 GHz band with a spectral resolution of 44 kHz. Average thermal and dielectric properties of the nucleus have been derived from the continuum measurements in Ref. 2, 3 and 4, and coma properties were obtained in Ref. 2, 5 and 6.

The reference publications relied on thermal models of the sub-surface regions of the nucleus for the analysis of continuum data, and on models of the coma density, gas velocity, and temperature, and on radiative transfer calculations for the analysis of the molecular lines. These two types of analyses were mostly conducted without explicit consideration for the coupling that exists between the thermal models and gas production models. Consequently, gas production rates derived from the spectral data analysis are not necessarily consistent with the temperature profiles obtained from the continuum data analysis, where sublimation of ices was not included. We will present results from a unified analysis of the continuum emission and the molecular lines for a set of observations in 2015, including two flybys with closest approach to the nucleus smaller than 10 km.

Our analysis constrains the physical properties of the sub-surface material of the nucleus, such as its porosity, ice-to-dust ratio, thickness of the dust layer, and dust grain size, by using a thermal model for porous materials similar to the one described in Ref. 7, including sublimation of ice, and a combination of simple hydrodynamic and gas kinetic models to compute the resulting properties of the gas column probed with MIRO. Non-local thermal equilibrium radiative transfer calculations yield the spectral line shapes. As part of the analysis of the sub-surface nucleus materials, we will compare the model parameters used in the independent thermal and spectral, and combined model approaches.

Acknowledgements

Part of this work was conducted at the Jet Propulsion Laboratory, California Institute of Technology, under contract to the National Aeronautics and Space Administration (NASA). Part of the research was carried out at the Max-Planck-Institut für Sonnensystemforschung with financial support from Deutsches Zentrum für Luft- und Raumfahrt and Max-Planck-Gesellschaft. Parts of the research were carried out by LESIA and LERMA, Observatoire de Paris, with financial support from CNES and CNRS/Institut des Sciences de l'Univers. Part of the research was carried out at the National Central University with funding from the Taiwanese National Science Counsel grant NSC 101-2111-M-008-016.

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