



HAL
open science

Measuring the $^{34}\text{S}/^{32}\text{S}$ isotopic ratio in CS_2 at comet $67\text{P}/\text{Churyumov-Gerasimenko}$

Antea Carine Doriot, Kathrin Altwegg, Jean-Jacques Berthelier, Robin Bonny, Michael Combi, Nora Hänni, Johan de Keyser, Daniel Müller, Stephen Fuselier, Martin Rubin, et al.

► To cite this version:

Antea Carine Doriot, Kathrin Altwegg, Jean-Jacques Berthelier, Robin Bonny, Michael Combi, et al.. Measuring the $^{34}\text{S}/^{32}\text{S}$ isotopic ratio in CS_2 at comet $67\text{P}/\text{Churyumov-Gerasimenko}$. Europlanet Science Congress 2024, Sep 2024, Berlin, Germany. pp.EPSC2024-421, 10.5194/epsc2024-421 . insu-04677224

HAL Id: insu-04677224

<https://insu.hal.science/insu-04677224v1>

Submitted on 25 Aug 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Measuring the $^{34}\text{S}/^{32}\text{S}$ isotopic ratio in CS_2 at comet 67P/Churyumov–Gerasimenko

Antea Carine Doriot¹, Kathrin Altwegg¹, Jean-Jacques Berthelier², Robin Bonny¹, Michael Combi³, Nora Hänni¹, Johan De Keyser⁴, Daniel Müller¹, Stephen Fuselier^{5,6}, Martin Rubin¹, and Susanne Wampfler⁷

¹Space Research and Planetary Sciences, Physics Institute, University of Bern, Sidlerstrasse 5, CH-3012 Bern, Switzerland (antea.doriot@unibe.ch)

²Laboratoire Atmosphères, Milieux, Observations Spatiales, Institut Pierre Simon Laplace, CNRS, Université Pierre et Marie Curie, 4 Avenue de Neptune, F-94100 Saint-Maur, France

³Department of Climate and Space Sciences and Engineering, University of Michigan, 2455 Hayward, Ann Arbor, MI 48109, USA

⁴Royal Belgian Institute for Space Aeronomy, BIRA-IASB, Ringlaan 3, B-1180 Brussels, Belgium

⁵Space Science Directorate, Southwest Research Institute, 6220 Culebra Rd., San Antonio, TX 78228, USA

⁶Department of Physics and Astronomy, The University of Texas at San Antonio, San Antonio, TX 78249, USA

⁷Center for Space and Habitability, University of Bern, Gesellschaftsstrasse 6, CH-3012 Bern, Switzerland

Comets are thought to be relatively unaltered remnants from the protosolar nebula. Studying their composition may therefore give valuable clues about the processes that governed the formation and evolution of our Solar System. Since the 1980's, several missions were launched with the objective to study comets in situ, the most recent one being ESA's Rosetta mission in March 2004. Rosetta underwent a decade-long journey in space before reaching its target comet 67P/Churyumov–Gerasimenko (hereafter 67P) in early August 2014, accompanying it for two more years until end of September 2016 on its orbit around the Sun while continuously taking measurements providing an extensive amount of scientific data. One of the instruments onboard Rosetta was DFMS (Double Focusing Mass Spectrometer) of the ROSINA (Rosetta Orbiter Spectrometer for Ion and Neutral Analysis) suite (Balsiger et al. 2007), utilized to measure in situ volatile gases in 67P's coma (cf. Rubin et al. (2019) for a review).

A notable result from the Rosetta mission is the measurement by Altwegg et al. (2017) of a $\text{D}_2\text{O}/\text{HDO}$ -to- $\text{HDO}/\text{H}_2\text{O}$ ratio much higher than expected from statistics at thermal equilibrium (17 versus 0.25), suggesting that the ice of 67P formed at very low temperatures and remained cold. Another implication is that species embedded within the ice retain their presolar abundance. In addition, various isotopic ratios of volatiles were found to be non-solar, supporting the hypothesis of a heterogeneous protoplanetary nebula (cf. Altwegg et al. (2019) and references therein). Sulphur, the tenth most abundant element in the Universe, has four stable isotopes: ^{32}S , ^{33}S , ^{34}S and ^{36}S , with relative abundances 94.93%, 0.76%, 4.29%, and 0.02%, respectively, according to the V-CDT standard (Ding et al. 2001). For comet 67P, Calmonte et al. (2017) determined the isotopic ratios $^{34}\text{S}/^{32}\text{S}$ and $^{33}\text{S}/^{32}\text{S}$ for three sulphur-bearing molecules in the coma, namely H_2S , OCS and CS_2 , and

found that the isotopic abundances for ^{33}S and ^{34}S , relative to the most abundant one, ^{32}S , are depleted in the coma compared to the V-CDT standard. Their relative difference to the V-CDT standard value is $\delta^{33}\text{S} = (-302 \pm 29)\text{‰}$ and $\delta^{34}\text{S} = (-41 \pm 17)\text{‰}$, respectively.

In this work, we extract the $^{34}\text{S}/^{32}\text{S}$ isotopic ratio in CS_2 in the coma of 67P using in situ measurements from DFMS. We analyze data during equinox in March 2016, when carbon disulphide had a high production rate and Rosetta was within 10 km from the nucleus centre. Complementary to Calmonte et al. (2017), we include the CS_2 isotopologue containing the same heavy sulphur isotope twice, namely C^{34}S_2 , in the analysis and deduce $^{34}\text{S}/^{32}\text{S}$ from both the ratio of $\text{C}^{34}\text{S}_2/\text{C}^{34}\text{S}^{32}\text{S}$ and $\text{C}^{34}\text{S}^{32}\text{S}/\text{C}^{32}\text{S}_2$ for comparison to the expected statistical values at thermal equilibrium.

References

- Altwegg, K., Balsiger, H., Berthelier, J. J., et al. 2017, *Philos. Trans. R. Soc., A*, 375, 20160253
Altwegg, K., Balsiger, H., & Fuselier, S. A. 2019, *Annu. Rev. Astron. Astrophys.*, 57, 113
Balsiger, H., Altwegg, K., Bochsler, P., et al. 2007, *Space Sci. Rev.*, 128, 745
Calmonte, U., Altwegg, K., Balsiger, H., et al. 2017, *MNRAS*, 469, S787
Ding, T., Valkiers, S., Kipphardt, H., et al. 2001, *Geochim. Cosmochim. Acta*, 65, 2433
Rubin, M., Bekaert, D. V., Broadley, M. W., Drozdovskaya, M. N., & Wampfler, S. F. 2019, *ACS Earth Space Chem.*, 3, 1792