PRESS RELEASE

First Identification of Calcium Sulfide in the Interstellar Medium

An international team of scientists led by the Centro de Astrobiología (CAB), CSIC-INTA, has achieved the first identification of CaS in the interstellar medium. This finding expands the chemical inventory and paves the way for the search for other refractory compounds that may shed light on where and how sulfur is stored in the Universe.

04-11-2025

An international team led by the Centro de Astrobiología (CAB, CSIC-INTA) has revealed a new finding in astrochemistry: identifying the sulfur-bearing refractory molecule CaS for the first time in the interstellar medium. The presence of this key molecule provides insights in both the sulfur chemistry and the processes leading to the formation of calcium- and aluminum- rich inclusions (CAIs), which are considered the oldest materials in the Solar System. Additionally, the refractory compounds KS and KSH were also tentatively detected.

The CaS was discovered in the massive disk G351.77-mm1, one of the very few disks in which the the refractory compound NaCl has also been detected. These species are very difficult to detect because they are only released to the gas-phase under very limited conditions (e.g., extremely high temperatures, intense radiation, strong shocks). The ultra-high angular resolution provided by Atacama Large Millimeter/submillimeter Array (ALMA) in Chile is necessary to probe the emission from the innermost regions of the disk, where these molecules are expected to be released into the gas phase. The newly detected refractory compounds offer therefore an unprecedented opportunity to determine the sulfur content in these harsh environments.

By comparing the abundances of these refractory species with those of volatile sulfur compounds such as SO_2, CH_3SH, or SiS, astrochemists concluded that they do not constitute major reservoirs of sulfur. However, further chemical modeling and a higher angular resolution would be necessary to better constrain their abundances and understand their formation pathways from the material released from grains.

The researchers believe that sulfur-bearing refractory compounds could still play a key role in solving the long-standing “missing sulfur problem”: finding where the large fraction of the sulfur expected from cosmic abundances is hidden. In this context, the presence of species such as SiS, as well as CaS, KS and KSH, makes this disk an ideal target to continue searching for allotropes and other refractory molecules.

This discovery represents an important advance toward completing the chemical inventory of the interstellar medium and improving our understanding of sulfur chemistry – a fundamental component in the evolution of planetary materials and the early stages of Solar System formation.

About CAB

Centro de Astrobiología (CAB) is a joint research center of the National Institute of Aerospace Technology (INTA) and the National Research Council (CSIC) of Spain. Created in 1999, it was the world's first center dedicated specifically to astrobiological research and the first non-US associate member of NASA's Astrobiology Institute (now the NASA Astrobiology Program). It is an interdisciplinary research center whose main objective is to study the origin, presence and influence of life in the universe from a transdisciplinary approach. In 2017, CAB was distinguished by the Ministry of Science and Innovation as "María de Maeztu Unit of Excellence".

CAB has led the development of the REMS, TWINS and MEDA instruments, all operational on Mars since August 2012, November 2018 and February 2021, respectively; as well as the science of the RLS and RAX Raman instruments, which will be launched in this decade on board of ExoMars and MMX missions. In addition, CAB develops the SOLID instrument, aimed at the search for life in planetary exploration. Likewise, CAB participates in different missions and instruments of great astrobiological relevance, such as CARMENES, CHEOPS, PLATO, BepiColombo, DART, Hera, the MIRI and NIRSpec instruments at JWST and the HARMONI instrument at ESO's Extremely Large Telescope (ELT).

More information

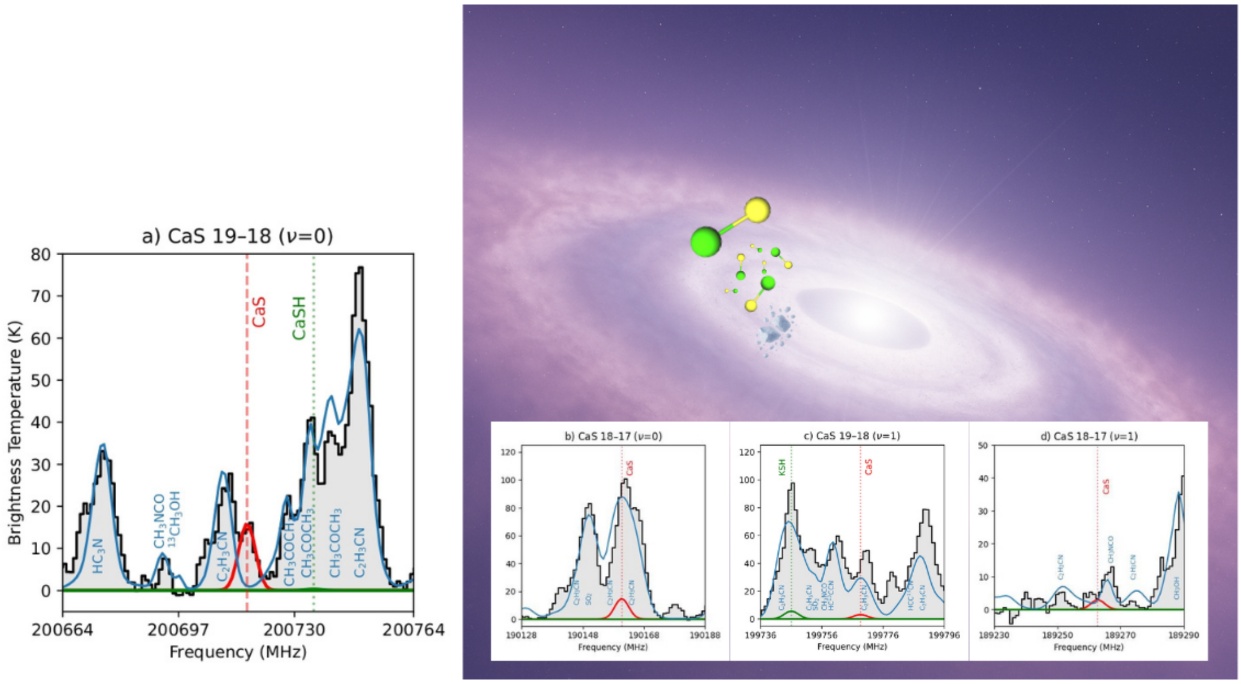

Figure 1. Zoom-in panels around the CaS transitions as observed toward the G351.77-mm1 disk. Image credit: ESA/Webb, ESO/L. Calçada. *Color modification by A. Tasa-Chaveli.*

Scientific paper published in *The Astrophysical Journal Letters*

"**A Quest for Sulfur-bearing Refractory Species: Identification of CaS in the Interstellar Medium**" by Aitana Tasa-Chaveli, Álvaro Sánchez-Monge, Asunción Fuente, Adam Ginsburg, Holger Müller, Thomas Möller, Pablo Rivière-Marichalar, David Navarro-Almaida, Gisela Esplugues, Peter Schilke, Marina Rodríguez Baras, Sven Thorwirth and Leire Beitia-Antero, ApJL 993 L42, DOI: 10.3847/2041-8213/ae0e6b https://iopscience.iop.org/article/10.3847/2041-8213/ae0e6b

Contact:

CAB researchers:

Aitana Tasa-Chaveli: atasa (+@cab.inta-csic.es)

FUNDING

'This work is supported by ERC grant SUL4LIFE, GA No. 101096293' 'Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Council Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.'
The authors also thank project PID2022-137980NB-I00 funded by the Spanish Ministry of Science and Innovation/State Agency of Research MCIN/AEI/10.13039/501100011033 and by "ERDF A way of making Europe".

Funded by the European Union | European Research Council, Established by the European Commission | MINISTERIO DE CIENCIA E INNOVACIÓN | UNIÓN EUROPEA, FONDO EUROPEO DE DESARROLLO REGIONAL "Una manera de hacer Europa" | AGENCIA ESTATAL DE INVESTIGACIÓN

CAB SCIENTIFIC CULTURE UNIT (UCC)

divulgacion (+@cab.inta-csic.es); (+34) 915202107

GOBIERNO DE ESPAÑA | MINISTERIO DE CIENCIA E INNOVACIÓN | FECYT FUNDACIÓN ESPAÑOLA PARA LA CIENCIA Y LA TECNOLOGÍA | UCC+i RED DE UNIDADES DE CULTURA CIENTÍFICA Y DE LA INNOVACIÓN

GOBIERNO DE ESPAÑA | MINISTERIO DE DEFENSA | INTA Instituto Nacional de Técnica Aeroespacial