Synchrotron FTIR Examination of Interplanetary Dust Particles: An Effort To Determine the Compounds and Minerals in Interstellar and Circumstellar Dust

George J. Flynn
Dept. of Physics, SUNY-Plattsburgh, Plattsburgh, NY

Much of what we know about the grains in the interstellar medium (ISM) and surrounding other stars comes from infrared (IR) spectroscopy, which generally provides identification of solid compounds and minerals in the dust. But the IR signature of that compound or mineral must have been measured in the laboratory for comparison. Interstellar grains (ISGs) show broad 10 and 18 μm absorptions that suggest a disordered silicate, and features near 3 μm consistent with aliphatic C-H. Circumstellar grains (CSGs)include crystalline and glassy silicate, oxides, and other phases, many yet unidentified.

NASA collects interplanetary dust particles (IDPs), dust from comets and asteroids, from the Earth's stratosphere. Many IDPs are very primitive, and some show very high D/H, making them good candidates for the preservation of ISGs. The IDPs are sub-micron aggregates of minerals and compounds, requiring the high intensity of synchrotron-based FTIR to obtain spectra of their individual subunits. We characterize the IR absorption of the components of IDPs to identify the minerals in ISGs and CSGs.

Bradley (1994) suggested 0.5 μm glass subunits (Glass with Embedded Metal and Sulfides, GEMS) in IDPs were good candidates for interstellar silicate. We measured the FTIR spectra of GEMS in a primitive IDP. They are an excellent match to the 10 μm interstellar feature [2] and the 18 μm feature of GEMS also matches the interstellar feature. This is the first time any single, naturally occurring material has matched the interstellar 10 and 18 μm features. GEMS are either interstellar silicates or good laboratory analogs.

In Infrared Space Observatory (ISO) spectra of some cold, dense molecular clouds and around some evolved stars, there is a broad 23.5 μm emission, attributed to FeO based on modeling. We measured the FTIR spectra of wustite (FeO) and another Fe-oxide (magnetite). Both have a strong feature at 17.5 μm, not seen in the ISO spectra, excluding FeO as source of the 23.5 μm feature. We measured an Fe-sulfide standard (pyrrhotite) and Fe-sulfides in two IDPs. The pyrrhotite standard is an excellent match to the ISO feature, indicating pyrrhotite is a previously unrecognized interstellar and circumstellar grain [3].

We measured C-H stretching vibrations of the IDPs. The ratio of the C-H2 to the C-H3 absorption features is a measure of the length of the aliphatic molecule. The more intense C-H3 absorption, relative to C-H2, in the interstellar feature compared to the IDPs indicates that the aliphatic chain is shorter in the interstellar material than in the interplanetary dust.

References:

[1] Bradley, J., *Science*, **265**, 925-928, 1994.
[2] Bradley, J. R. *et al.,* (1999), *Science*, **285**, 1716-1718.
[3] Keller, L. P., *et al.,* (2000)., *Lunar Planet. Sci.* XXXI, A # 1860.
[4] Flynn, G. J., *et al.,* (2000), in *Bioastronomy '99, ASP Conf.* **213**, 191-194.