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Calcite in solar-type protostars

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The analysis of the spectra in the FIR obtained with the Long Wavelength Spectrometer (LWS) on board the Infrared Space Observatory (ISO) have shown a dust feature between 90 and 110 micron in about half of the surveyed 32 solar-type protostars (Ceccarelli et al. 2002 A&A 395, L29; Chiavassa et al. 2005 A&A 432, 547). The observed feature compares quite well with the calcite spectrum obtained at the laboratory, and implies that about 10% of elemental Calcium is locked into calcite. Remarkably, approximately the same amount of calcite has been recently found in comets (Lisse et al. 2006, Science 313, 635).

The detection of calcite in solar-type protostars, whose luminosity is less than 100 Lo and dust temperature lower than about 50K, represents a new frontier in carbonate formation theories. In fact, calcite is usually attributed to aqueous alteration in solar system objects (on Earth or in meteorites). Lately, Toppani et al. (2005 Nature 437, 1121) have demonstrated that carbonates can be formed with amorphous silicates during the non-equilibrium condensation of a silicate gas in a H_2O-CO_2-rich vapour, in H_2O(g)-CO_2(g)-rich, high-temperature and high-density regions (as in planetary nebulae). However, also this mechanism cannot be responsible for the calcite in the low-luminosity protostars. Ceccarelli et al (2002) suggested that the X-rays copiously emitted from the central object could locally heat the circumstellar dust grains (see e.g. Favata et al. 2005 A&A 433, 1047), increasing the mobility of the water molecules in the grain ice mantles and, thus, simulating the liquid water conditions. If confirmed, the same mechanism may also be at the basis of the formation of the complex organic molecules observed in the Hot Corinos of solar-type protostars (e.g. Ceccarelli et al. 2006, Protostar & Planets V) and, more in general, of possible pre-biotic molecules.