Raman Micro-Spectroscopy performed on Extraterrestrial Particles. S. De Angelis[1,2], V. Della Corte[1], G. A. Baratta[3], R. Brunetto[4], P. Palumbo[1], A. Ciucci[1], A. Rotundi[1]
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Introduction:
We performed Raman measurements on stratospheric particles collected by the balloon-borne DUSTER (Dust in the Upper Stratosphere Tracking Experiment and Retrieval) instrument (Della Corte et al. 2011).
DUSTER is designed to collect particles, with sizes between 0.1 and 40 microns, in the upper stratosphere, at altitudes of 35-40 km; the aim is to collect micron-size cosmic particles settling in the terrestrial atmosphere. The DUSTER instrument has flown in 2006 from Kiruna-Esrange (Sweden, technical flight), in 2008 and 2009 from Svalbard (Norway, scientific flights) and a new scientific flight is planned from Kiruna-Esrange for the end of February 2011. The particles on which we performed Raman measurements were collected during the DUSTER 2008 flight, at an altitude of 37±1 km in the polar stratosphere. The particles analyzed by Raman micro-spectroscopy, (sizes 3 – 12 micron) have been previously characterized by IR micro-spectroscopy, Field Emission Scanning Electron Microscopy (FESEM) and Energy Dispersive X-ray analyses. The Raman spectra are characterized by an intense signal due to amorphous carbon, with the typical D and G peaks at 1361 cm^{-1} and 1580 cm^{-1} superimposed to a fluorescence continuum. In two spectra, relative to particles D08C_006 and D08C_008(b), we can tentatively recognize the presence of a weak peak at 1080 cm^{-1} that could be due to calcite. The peak is hardly distinguishable from the noise of the relatively strong fluorescence background due to the presence of amorphous carbon. The presence of calcite ($CaCO_3$) is confirmed by IR micro-spectroscopy and by EDX analyses results. To support Raman spectra reduction, we developed a program (LabVIEW environment) able to fit many spectra simultaneously, choosing between Gaussian, Lorentzian or BWF curves for the fits.
We compared the Raman results obtained on DUSTER particles, whose origin has been classified as extraterrestrial, with two other sets of Raman analyses performed on extraterrestrial dust: 1) Interplanetary Dust Particles (IDPs), collected by the high flying aircraft stratospheric NASA programm; 2) cometary particles collected during the fly-by of the NASA/Stardust spacecraft in the coma of the comet 81P/Wild 2.
The Raman NASA/IDPs measurements show the presence of the D and G peaks of amorphous carbon, together with the evidence of iron-oxides (magnetite, maghemite and hematite) for all particles except one, in which the intense amorphous carbon signal dominates on possible minerals contribution. The presence of iron-oxides, combined with FESEM images and IR micro-spectroscopy, suggests that these IDPs could have undergone pyrometamorphism because of the flash-heating during atmospheric entry.
The Raman spectra of 81P/Wild 2 samples are dominated by condensed aromatic hydrocarbons (or "disordered carbonaceous material"). The D and G Raman parameters span a range similar to that observed in IDPs and in most primitive meteorites.
Raman analyses were performed at the INAF-Laboratorio di Astrofisica Sperimentale, Catania, Italy.