PT06-5

Electron irradiation of a-C:H deposits: Effects of cosmic rays on interstellar carbonaceous dust

Belén Maté[1], Germán Molpeceres[1], Miguel Jiménez-Redondo[1], Isabel Tanarro[1], Rafael Escribano[1], and Víctor J. Herrero (*)[1]

[1] *Instituto de Estructura de la Materia, IEM-CSIC, Serrano 123, 28006 Madrid, Spain*
(*) v.herrero@csic.es

Deposits of plasma-generated hydrogenated amorphous carbon, termed a-C:H or HAC, were irradiated with 5 keV electrons to simulate the electron cascades produced in the interaction of cosmic rays with solid particles. A destruction rate for CH bonds was derived from the evolution of the 3.4 μm IR absorption band. The results are in good agreement with the most recent ion irradiation data and show that cosmic rays alone cannot justify the disappearance of the 3.4 μm band in the interior of dense clouds.

The 3.4 μm IR absorption band is widely observed in the diffuse interstellar medium and is also found in extragalactic sources [1], [2]. It is assigned to CH stretching vibrations of aliphatic CH_3 and CH_2 groups. In the diffuse interstellar medium, aliphatic structures in carbonaceous particles are formed through their interaction with H atoms and are destroyed by UV photons and cosmic rays, CRs. In dense molecular clouds, protected from galactic UV photons, the 3.4 μm is not found, and its absence is a matter of debate. In these environments hydrogenation ceases largely due the recombination of H atoms to H_2 molecules and to the formation of a protective ice layer on dust grains, but CR bombardment continues unabated. Irradiation of carbonaceous dust analogs with 30 keV He^+ ions by Mennella et al.[3] suggested that CRs could be responsible for the disappearance of the 3.4 μm band in dense clouds. However, later experiments by Godard et al. [4], carried out with multiple ions at several energies, led to the conclusion that CR destruction of CH bonds should be negligible within the lifetime of a typical molecular cloud.

In this work we have used 5 KeV electrons and a-C:H deposits to simulate the effect of CRs on the aliphatic component of interstellar carbonaceous dust. To a first approximation, high energy electrons and ions interact in a similar way with matter, and their effects depend essentially on the deposited energy dose. The a-C:H samples used as dust analogs were generated in CH_4/He inductively coupled RF plasmas and were then transferred to a high vacuum chamber for electron irradiation and IR spectroscopy. Details of the experimental procedure can be found in [5]. CH destruction cross sections were estimated from the decay of the 3.4 μm band of a-C:H as a function of electron fluence, and the monoenergetic proton approximation [3] was used for the derivation of interstellar CH bond destruction rates.

The destruction rates from our experiments corroborate the values of Godard et al. [4], and are an order of magnitude lower than those from Mennella et al. [3]. In accordance with Godard et al. we conclude that CRs should not cause an appreciable decrease of the 3.4 μm band over a time of existence of a dense cloud (10^7 years). Alternative mechanisms are needed to justify the disappearance of this band in the transition between diffuse and dense interstellar clouds.

References

[1] J.E. Chiar, A.G.G.M. Tielens, A.J. Adamson, A. Ricca, *Astrophys. J.* **770** (2013) 78.
[2] E. Dartois, T. G. Geballe, T. Pino, et al. *Astron. Astrophys.* **463** (2007) 635.
[3] V. Mennella, G. A. Baratta, A. Esposito, G. Ferini, and Y. J. Pendleton, Astrophys. J. **587** (2003) 727.
[4] M. Godard, G. Féraud, M. Chabot et al. *Astron. Astrophys.* **529** (2011) A146
[5] B. Maté, I. Tanarro, R. Escribano, M. A. Moreno, and V. J. Herrero, *Astrophys J.* **806** (2015) 151