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Ion irradiation experiments relevant to the astrophysics ices

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Methane (CH_4) and methanol (CH_3OH) ices are present in various astrophysical environments, from dense molecular clouds to several small objects in the outer solar system, in particular on Saturn satellite Triton and to be a constituent of the icy mantle on interstellar grain [1]. There is a clear lack of information about the phenomena induced by the heavy-ion component of cosmic-rays in the electronic-energy-loss regime.

In this work, the chemical and physical effects induced by fast heavy ions irradiation on frozen pure methane and methanol at 15 K are studied. Measurements were performed at the medium energy beam-line of the heavy ion accelerator GANIL (Grand Acc\'el\'erateur National d'Ions Lourds), Caen-France [2]. The analysis was done by infrared spectroscopy (FTIR) during irradiation by 220 MeV $^{16}O^{7+}$ ion beam. For the case of methane, the principal molecular species identified as a product after irradiation are: CH_3, C_2H_2, C_2H_4, C_2H_6 and C_3H_8. For methanol ices are: H_2CO, CH_2OH, CH_4, CO, CO_2, HCO and $HCOOCH_3$ other products are identified with ambiguity. Their formation and dissociation cross sections are determined. The cross section of CH_4 and CH_3OH and its daughters species follows a power law as a function of the electronic stopping power. It is found that, some daughters species cross sections increase with the electronic stopping power roughly as $\sigma \propto S_e^{3/2}$. As astrophysical implication, the S_e^n power law, where $n \approx 3/2$ should be very helpful for predicting the CH_4 and CH_3OH formation and the dissociation cross sections for other ion beam projectiles and energies in the ISM rich in hydrocarbons that are continuously bombarded by cosmic rays.

Orateur: M. MEJÍA GUAMÁN, Christian Fernando (PUC Rio)

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