The flux of cosmic rays and the physical conditions in the Central Molecular Zone of our Galaxy inferred by H_3^+

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The Central Molecular Zone (CMZ) is the region spanning over 200 pc around the central Black Hole of our galaxy, Sgr A*. The nature and physical conditions of this area has been a long subject of debate. H_3^+ has been detected on more than 10 lines of sight in this region [1]. These detections are surprising and characteristic of very specific processes taking place in our Galaxy Center. First, H_3^+ has column densities 10 times higher in the CMZ than in typical diffuse interstellar clouds. Second, it is detected in its (3,3) metastable level that is not observed elsewhere. This indicates that a large fraction of the Central Molecular Zone of our Galaxy must be filled with diffuse neutral gas (< 500 cm-3) and that mechanisms heat this gas at about ~400 K (whereas standard diffuse clouds, heated by photo-electric effect, have a temperature of 60 K).

Several authors, of the ISM community, but also of the high energy astrophysics community, tried to infer the physical conditions in the CMZ. Most of these studies are based on H_3^+ observations or on tracers of cosmic rays as the synchrotron emission from the CMZ [2]. In these works, the large abundance of H_3^+ is explained by an intense flux of cosmic rays, about 10-100 times higher in the CMZ than in typical diffuse clouds. Nevertheless, no consistent explanation has been proposed to explain both, the large abundance of H_3^+ and its unusual excitation / temperature of the gas. The most common proposition is to assume that shocks or turbulence could be an important source of heating that would excite H_3^+.

In this talk, we will present a comprehensive model of the physical conditions and processes in the Central Molecular Zone of our Galaxy. This model has been obtained with the new version of the Meudon PDR code [3] in which recent H_3^+ + H_2 collision rates [4] have been implemented. We will first show that the column density of H_3^+ is not proportional to the flux of cosmic rays under the exotic conditions of the CMZ (on the opposite to classical ISM). We will then show that a detailed treatment of the physics of grains and PAHs - that control H_2 formation and electrons recombination - has a strong influence on the abundance of H_3^+. On the opposite to classical models, thanks to detailed treatment of the physical processes, we find for the first time a scenario that explains both the abundance of H_3^+ and its unusual excitation. It it then possible to better constrain the properties of the CMZ. We will show, that this scenario is also compatible with the conclusions of specialists of high energy astrophysics studying the CMZ with synchrotron emission.

References

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