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H_2 formation on interstellar grains

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Abstract. Molecular hydrogen is the most abundant molecule in the Universe and dominates the mass budget of the gas, particularly in regions of star formation. H_2 is also an important chemical intermediate in the formation of larger species and can be an important gas coolant when the medium lacks metals. Because of the inefficiency of gas phase reactions to form H_2, this molecule is generally thought to form on grain surfaces. Observations of H_2 in a wide variety of objects showed that this molecule could form efficiently for a wide range of physical conditions. To understand the mechanism responsible for such an efficient formation, we developed a model for molecular hydrogen formation on grain surfaces. This model considers the interaction between atom and surface as beeing either weak (Van der Waals interaction - physisorption) or strong (covalent bound - chemisorption) as well as the mobility of the atom on a surface due to quantum mechanical diffusion and thermal hopping. This model solves the time dependent kinetic rate equation for the formation of molecular hydrogen and its deuterated forms. Our results have been benchmarked with laboratory experiments on silicates, carbonaceous and graphitic surfaces. This comparison allowed us to derive some characteristics of the considered surfaces. An extension of our model to astrophysical conditions gives an estimate of H_2 formation efficiency for a wide range of physical conditions. One of our main result is the efficient formation of molecular hydrogen for gas and grain temperatures up to several hundreds of kelvins. We also compared our predictions to observations in astrophysical objects such as photodissociation regions (PDR), diffuse clouds and dark clouds.

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