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Rapid formation of molecular clouds from turbulent atomic gas

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Abstract. The characteristic lifetimes of molecular clouds remain uncertain and a topic of frequent debate, with arguments having recently been advanced both in support of short-lived clouds, with lifetimes of a few Myr or less (see e.g. Elmegreen 2000; Hartmann et al. 2001) and in support of much longer-lived clouds, with lifetimes of the order of 10 Myr or more (see e.g. Tassis & Mouschovias, 2004; Goldsmith & Li, 2005). An argument that has previously been advanced in favour of longer lived clouds is the apparent difficulty involved in converting sufficient atomic hydrogen to molecular hydrogen within the short timescale required by the rapid cloud formation scenario. However, previous estimates of the time required for this conversion to occur have not taken into account the effects of the supersonic turbulence which is inferred to be present in the atomic gas.

In this contribution, we present results from a set of high resolution three-dimensional simulations of turbulence in gravitationally unstable atomic gas. These simulations were performed using a modified version of the ZEUS-MP hydrodynamical code (Norman 2000), and include a detailed treatment of the thermal balance of the gas and of the formation of molecular hydrogen. The effects of photodissociation of H_2 by the Galactic UV field are also included, with a simple local approximation used to compute the effects of H_2 self-shielding.

The results of our simulations demonstrate that H_2 formation occurs rapidly in turbulent atomic gas. Starting from purely atomic gas, large quantities of molecular gas can be produced on timescales of less than a Myr, given turbulent velocity dispersions and magnetic field strengths consistent with observations. Moreover, as our simulations underestimate the effectiveness of H_2 self-shielding and dust absorption, we can be confident that the molecular fractions which we compute are *strong lower limits* on the true values. The formation of large quantities of molecular gas on the timescale required by rapid cloud formation models therefore appears to be entirely plausible.

Keywords. astrochemistry – hydrodynamics – ISM: clouds – ISM: evolution – ISM: molecules

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