

Superdiffusion in molecular clouds

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Abstract. Turbulence has a significant influence on the chemistry of molecular clouds. Do molecular abundances alter if we use superdiffusion instead of simple diffusion? After our first simplified calculations it seems there is a notable difference.

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Several (pseudo-)time-dependent models have been developed after the initial steady state gas-phase chemistry models to determine the fractional abundances in molecular clouds. Our calculations were based mostly on diffusivities and timescales of Xie, Allen & Langer (1995), and we studied what differences occur if we use superdiffusion instead of simple diffusion. After Petrovay (1999) we can speak about a 'scale-dependent diffusivity': $D(r) = K'^2 = K^{1/\zeta} r^{2-1/\zeta}$. Thus using superdiffusion we can take into account eddies with different sizes, namely the eddies exceeding the separation r do not contribute to the further separation of fluid parcels at separation r .

First we studied a simplified model neglecting the chemical processes and approximating the source term by means of the diffusionless solution based on relaxation timescales of the above mentioned paper. Our cloud was spherically symmetric with constant density of H₂. Thus the equation of diffusion: $\frac{\partial n}{\partial t} = D\nabla^2 n + \frac{(n_0 - n)}{\tau_c}$, where n_0 is the diffusionless solution of number density of a tracer and τ_c is the characteristic time. Transforming this partial differential equation into the Fourier space one can get the stationary solution solving a simple algebraic equation. In the superdiffusive case we assumed Kolmogorov spectra ($\zeta = \frac{3}{2}$) and scaled the diffusivity according to the formula: $D = D_0 \left(\frac{k}{k_0}\right)^{-\frac{4}{3}}$, where k is the wavenumber and k_0 corresponds the correlation length of the cloud. Dropping the assumption of constant distribution of H₂ one may have difficulties with integral transform because of the product of operators and functions. Therefore introducing the function $F = -n_t \nabla \left(\frac{n}{n_t}\right)$ we get the following diffusion equation: $\frac{\partial n}{\partial t} = D\nabla F + \frac{(n_0 - n)}{\tau_c}$, and using an iterative method the density distribution of a tracer can be solved.

We can conclude that there is a significant difference between the diffusive and superdiffusive case. We plan to refine the approximation of the source term, taking into account that this diffusive process is more complicated than a simple mixing between the inner parts and the outer layers of the cloud.

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References

- Petrovay, K. 1999, *Space Sci. Revs* 95, 9
Xie, T., Allen, M. & Langer W.D. 1995, *ApJ* 440, 674