HIERARCHICAL FRAGMENTED STRUCTURE OF MOLECULAR CLOUDS PRODUCED BY SUPERSONIC TURBULENCE

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For GMC's the two prominent properties are typical. They consist of dense molecular gas clumps concentrating to the GMC centre and filling only a few percent of a total volume. And these clumps participate in chaotic motions with velocities v_t exceeding as a rule the sound velocity c_o at the temperature of molecular gas. This phenomenon is considered as a supersonic molecular cloud's turbulence. The compressibility of turbulent matter becomes very important with such velocities. Thus in application to GMC it is necessary to develop the theory of turbulence and fragmentation under transsonic and supersonic random motions. The hydrodynamic flow velocity field can be divided into the potential and vortical components. When transsonic or supersonic motions prevail the potential component is become more important that stimulates the shock wave's stochastic field development. Ohul'chansky (1988,Kinematics and Physics of Celestial Bodies 4,3) has described this process on the base of Burgers' equation treatment. In this paper we apply this approach for conditions of GMCs that permit the supersonic turbulence' spectrum evolution, the large density fluctuations development, and clumps formation to consider.

As was shown by Kolesnik (1987,Kinematics and Physics of Celestial Bodies 3, 47) the supersonic motions of molecular gas can be developed from subsonic turbulence of the warm gas when its temperature rapidly drops down to about 100 K.

The evolution of initial Kolmogorov's spectrum on the base of three-dimentional Burgers' equation was considered by Ohul'chansky(1988). Qualitevely the spectrum evolves from Kolmogorov's one with exponent -5/3 to more steeper ones,the exponent being appreciated from -2 to -3. The characteristic time of evolution depends on the wave number k.

The further evolution of turbulent medium is following.The range of the shock wave forming harmonics is moved into the smaller wave numbers k gradually. The interacting shock wave's ensemble is formed. Because of isothermal conditions the magnitude of density fluctuations can rise to the large values. Most dense clumps are formed when shock waves collide in head-on. This promotes to the filamentary structures formation in molecular clouds. On the other hand the oblique shock waves interac-

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tion practically doesn't increase the density fluctuation. It leads only to the decreasing of the angle between interacting oblique shock fronts. This also provokes the plane dense structure formation. Therefore in the evolving supersonic turbulent medium the flat dense structures will be pronounced more and more by the stochastic shock fronts interactions. The statistics of density peaks is determined by the totality of all multy-point joint probabilities of physical quantity and its derivatives. In Gauss case it is possible to derive the size distribution of fragments

$$(dN/d\lambda) \propto \lambda^{-2m-3},\ \lambda \geq \sqrt{\langle\lambda^2\rangle}\ ;\quad (dN/d\lambda) \propto \lambda,\ \ \lambda < \sqrt{\langle\lambda^2\rangle}\ .$$

Here λ is the clump's length scale.As it is seen the large scale clumps distribution is sensitive to the geometry of fragments. Received properties of the size distribution function can be used for conclusions what type of fragmentation processes is responsible for the clumps formation in the observing objects.The typical density in the centre of clumps may be appreciated in the following way. When accepting that filamentary flattened stuctures mainly are the consequence of collisions of shock waves,then it follows that for such structures $\Delta\rho/\rho_o \propto \langle Ma\rangle^4$ ($\langle Ma\rangle$ is the typical Mach number of shock waves), because in GMC the passing of one shock wave gives the velocity jump Ma^2. The quantity $\langle Ma\rangle$ is proportional to v_t/c_o , where v_t is the typical velocity of turbulent motions. The quantity $\langle\lambda\rangle$ is determined by the scale l_c (the scale l_c is the scale on which the turbulent velocity difference equals c_o) and by other space parameters of physical medium.These ones may be the typical size of eddies in primary stage of evolution of molecular cloud and also the typical scale of inhomogenity of cloud.

During the evolution of molecular cloud the following situation is possible. In the distinguished dense core of GMC the turbulence has lost the memory about the primordial hierarchy of eddies yet, and in the outer layers of GMC the system keeps the memory and the typical size of clumps corresponds to the size of eddies. Thus, in the outer layers the size of clumps is much greater than in the core. Besides, the interaction between the turbulent motions in the outer layers of cloud and inner dense core results to the strong compression of matter in the intermediate layer which may cause the violent star formation.