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A SINGLE FRAGMENTATION LAW? THEORETICAL AND OBSERVATIONAL EVIDENCE

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ABSTRACT. In the light of the growing interest for the modes of formation of various astronomical objects, a relevant amount of data were collected and treated to obtain mass spectra. Statistical comparisons of the data suggest that a single process drives the formation of the various self-gravitating objects.

Many authors (e.g. Larson 1973,1985, Silk 1977, Zel'dovich 1978) restricted their attention to the formation of a particular single class of objects (i.e. stars and clusters of galaxies), while Reddish, after

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comparing some observed mass spectra (stars, dust and molecular clouds, open clusters) with one another, explicitly stated that the high-mass tails of the spectra of the mentioned objects were not inconsistent with the view that "they are all formed by essentially the same process" (Reddish 1978, pag. 81). When Reddish proposed this view, no theory supporting this suggestive, simple and comprehensive picture was available. In recent times, such a theory, based on a statistical treatment of the well known process of gravitational instability, was suggested and developed by Di Fazio (1982,1985). All these considerations suggested us to collect the available observational data concerning masses or mass-related quantities, to assemble them into a homogeneous set of mass functions in order to compare them with one another and with the theoretical mass functions.

We treat the data in order to have homogeneous samples, and obtain frequency vs. mass histograms (see Figure 1). The original sources of the data are described in Di Fazio (1985), and in Di Fazio and Capuzzo Dolcetta (1986). LMC and SMC indicate Large and Small Magellanic clouds; 1 and 2 label two independent ways of obtaining masses (see Di Fazio and Capuzzo Dolcetta 1986).

A qualitative look at the various mass functions displayed in Figure 1 suggests a general common trend, characterized by: i) a cut-off at low masses, ii) a maximum displaced at the very left side of the mass range, iii) the distribution seem to be packed in the interval [0,2], iv) a slow decrease in the high mass tail, with similar slopes in all the considered cases. Of course these qualitative considerations imply a discussion of the degree of completeness of the considered samples (see Di Fazio and Capuzzo Dolcetta 1986).

The previous described qualitative shape similarities suggested us to actually perform quantitative statistically significant comparisons of the global characteristics of the distributions through Kolmogorov-Smirnov tests. The results of the tests, in terms of the critical level of confidence, α, that two samples have statistically the same shape, are: $0.86 < \alpha < 0.99$.

The quite good shape similarity existing among the various mass functions holds equally well between samples of very different nature, as well as between samples of related (or close) evolutionary histories. Remembering the completely different nature, location, chemical composition, and size of the considered objects, the striking similarities of the mass spectra can be ascribed to the only thing that all the objects could have in common: their formation process. This confirms and enlarges Reddish's hypothesis. A further independent evidence in favour of the gravitational instability is given by the various observed correlations between the ambient gas and the star formation rate (see e.g. Lequeux 1980). In fact, forcing the star formation rate to be simulated by a power law of the density alone, a slope in the range [0.5,1.4] is obtained, in good agreement with the observations.

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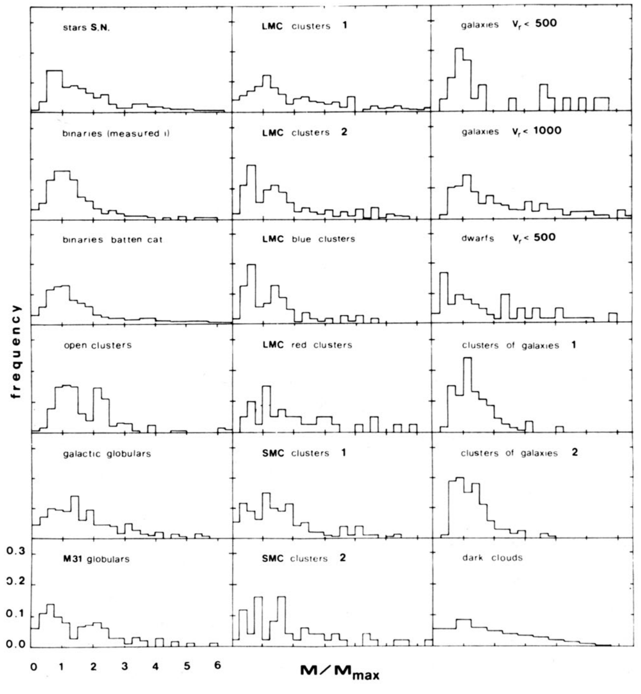

Fig. 1. Frequency vs. mass histograms for different families of astronomical self-gravitating objects, obtained in different ways (see text). The abscissa is the mass in units of the value of the peak mass of the distribution, M_{max}, obtained by appropriately fitted curves. The masses for LMC blue (i.e. B-V < 0.5) and red (B-V ≧ 0.5) clusters are obtained with method 2 (see text).

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