Cosmic strings and celestial objects

SIR—In a recent paper[1], Tassie has suggested that celestial objects have evolved through a hierarchical breaking of rotating pieces of cosmic string and that this would account for the angular momentum (J) for a wide variety of astronomical objects being proportional to the square of their masses, (M), the constant of proportionality moreover being comparable with that of some string theories of particle physics. So one has a relation $J = KM^2$, K being a universal constant whose value from an analysis of astronomical objects of different classes is $\sim 10^{-15}$ g^{-1} cm^2 s^{-1} and similarly for strings $J_S \approx K_S M^2$ with K_S being related to the string tension μ through $K_S = c(2\pi\mu)^{-1}$. For agreement with the astronomical value, that is $K = K_S$, this would imply a string tension of $\mu \approx 6 \times 10^{24}$ g cm^{-1}. It must first be pointed out that it is not necessary to invoke exotic configurations such as strings to understand the apparent $J = KM^2$ relation for celestial objects. In fact it can be shown[2] that just such a relation with a dimensional constant K close to the observed value, would arise naturally from considerations of the basic physics involved in the structure of various astronomical objects such as galaxies and stars. The relation in fact is an upper envelope relating maximum J to M^2. To within a factor of order unity, systems which are gravitationally bound have typical velocities $(V/c) \approx (R_G/R)^{1/2}$, R_G being the gravitational radius $(2GM/c^2)$. If $V^2/R \approx GM/R^2$ and $J = MVR$ we can write $J \approx (G/V)M^2$ which for $V \approx$ constant would imply an apparent $J \sim M^2$ relation. It is to be noted that the range of V or equivalently $(R_G/R)^{1/2}$ is rather narrow for astronomical objects, (as compared to the range of M), with 10^{-3} c being most typical. (Velocity V well below 10^{-4} c would be very difficult to observe and relativistic objects are rare.) Thus for $V \approx 10^{-3}$ c, $K \approx 10^{-15}$, which is the empirical result seen.

Apart from the fact that there is no need to invoke strings to account for the $J = KM^2$ relation, the value for the string tension μ, which the observed value of K would imply is unacceptably high. The reason being that the dominant energy loss mechanism for strings is by gravitational radiation with the power loss given by $P = \beta G\mu^2 c$, $\beta \approx 10$. This rate of energy loss is independent of the size of the string (it depends only on the tension μ). For a string of radius R this implies a lifetime $t \approx RC/\beta G\mu$. For galaxy-size loops $R \approx 1$ kpc, and with the above value of μ, this would give a lifetime of less than one per cent of a Hubble time, that is, they would not last long enough to form galaxies. A more stringent constraint[3] (C.S., in preparation) obtained by noting that the presence of an extra component (of gravitational radiation) or even less than 5% of the total radiation background at the epoch of nucleosynthesis can affect element abundances, give $\mu < 10^{20}$ g cm^{-1}. This makes it improbable that the value of μ determines the constant of proportionality in the J-M^2 relation; that is, the value of μ implied from this relation being incompatible with string models of galaxy formation.

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1. Tassie, L. J. *Nature* 323, 40-43 (1986).
2. Sivaram, C. in *Relativistic Astrophysics and Cosmology* (ed. de Sabbatta, V.) 228-246 (World Scientific, Singapore, 1984).