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Magnetic braking and low specific angular momenta of elliptical galaxies

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1. Introduction

Elliptical Galaxies are known to possess only about 5 per cent and the bulges only about 15 per cent of the specific angular momenta of spiral galaxies (Faber, 1982). One of the popular models for the formation of ellipticals is the merger hypothesis, whereby two spirals collide with each other and merge to form the ellipticals (Schweizer, 1986). While merger hypothesis has several merits, some observational problems have been raised like the near absence of type specific variance in the luminosity function (Bingelli *et al.* 1988). Hence it is useful to investigate an alternate scenario, which has a strong observational support and astrophysical significance. In this investigation, we are examining the possibility that the low specific angular momentum of elliptical galaxies is due to their rotation being braked by the large scale magnetic fields during the collapse phase of the protogalaxy.

2. Observational Data

There is a large body of evidence for the presence of magnetic field with strengths of the order of several tenths of microgauss over cluster sizes extending to over 100 Kpc or so (Kim *et al.* 1990). It is also known that strong radiogalaxies are predominantly ellipticals and strong radioemission in general means strong magnetic fields, though the scalelengths of these fields may be confined to local regions. Further equipartition arguments (Pacholezyk, 1970) too lead to fields of the order of 0.2-2 microgauss. Hence we may take the assumption of the presence of the fields of several tenths of microgauss extending to cluster sizes as eminently reasonable. It can be shown that these fields can be taken to be 'frozen in'. Under these circumstances the operation of magnetic braking phenomenon is very likely and one can estimate the timescales for the magnetic braking.

From the observational data referred to in the Introduction, one can estimate the amount of angular momentum to be carried away by magnetic braking. This is of the order of 10^{30}M. cm^2.S^{-1}.

3. Time scales

Our hypothesis of the efficiency of magnetic braking in removing the angular momentum of elliptical galaxies will be valid provided the braking timescale is less than the collapse timescale of the elliptical galaxies. The relevant mathematical expressions can be found in Mestel and Paris (1984) and Mouschovias and Paleologou (1980). These people have shown that the braking timescale $t_b = 2.4\, t_{ff}\, (B_c/B_{ext})$. We know that the collapse timescale t_{coll} will be larger than the t_{ff} if the cloud is supported by gravitationally fed random motions (Indulekha, 1992). Under these circumstances, the ratios of various timescales can be estimated for various initial radii R_0, Masses M and magnetic field strengths B_0. These are given in Table 1.

4. Conclusion

A close look at Table 1 immediately makes it clear that the magnetic braking hypothesis is able to offer a reasonable explanation of the low specific angular momenta of ellipticals. The observation of the presence of large number of ellipticals in the core of halo clusters is readily explicable by this hypothesis. Essentially the flux freezing condition implies the increase in magnetic field strength with increasing density leading to more efficient magnetic braking in the dense cores of the clusters.

Table 1. Ratios of timescales and relevant parameters.

M (in M_0)	R_0 in Kpc	B_0 in gauss	t_b/t_{ff}	t_c/t_{ff}
5×10^{10}	70	0.8	1.57	4.5
1×10^{11}	100	0.8	0.90	4.5
5×10^{11}	170	0.8	0.90	4.5

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