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The Bardeen-Petterson effect as the precession mechanism for the radio galaxy 3C 84 (NGC 1275)

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Abstract. In this work we propose the Bardeen-Petterson effect as the precession mechanism of the jet precession in NGC 1275. To check if this is true we have estimated the angular momentum ratio and the aligment timescale predict by the theory and compared with the numerical results presented in the literature. We were able to explain the precession period assuming an accretion disk with column surface density in the form of a power law with exponent $0.6<s<0.7$ and a black hole rotation with a spin of $0.23<a_*<0.4$.

1. Introduction

The radio galaxy 3C 84, also known as NGC 1275, is located at a distance of 75 Mpc in the center of Perseus Cluster. Its optical morphology and the existence two systems of hydrogen lines seem to suggest that this galaxy is the result of an ongoing merge of two galaxies. X-ray emission has been observed in the nuclear region as well as in the halo. Bubble-like structures with different position angles with respect to the center of the cluster are seen in the X-ray maps; it has been suggested that these bubbles are inflated by a precessing jet. Recently, 3D numerical simulations (Falceta-Gonçalves *et al.* 2010) showed that, under certain conditions, a precessing jet can inflate multiple pair of bubbles. Assuming that the Bardeen-Petterson effect (Bardeen & Petterson 1975) can be the responsible for the jet precession in NGC 1275, they found that a precession period of $\mathrm{T_{prec}} = 5\times10^7$ years and a ratio between the angular momenta of the accretion disc and of the black hole of 1.1 could reproduce the observed X-ray maps.

2. Bardeen-Petterson effect

Frame dragging produced by a black hole with angular momentum J_{BH} causes precession of a particle if its orbital plane is inclined relative to the equatorial plane of the black hole; this is knows as Lense-Thirring effect (Lense & Thirring 1918).

The combined action of the Lense-Thirring effect with the inner viscosity of the disc causes the alignment of the angular momenta of the disc and the Kerr black hole; this is knows as Bardeen-Petterson effect (Bardeen & Petterson 1975) and tends to affect only the innermost parts of the disc due to the short range of the Lense-Thirring effect, while the outer parts tend to remain in its original configuration. The transition radius between

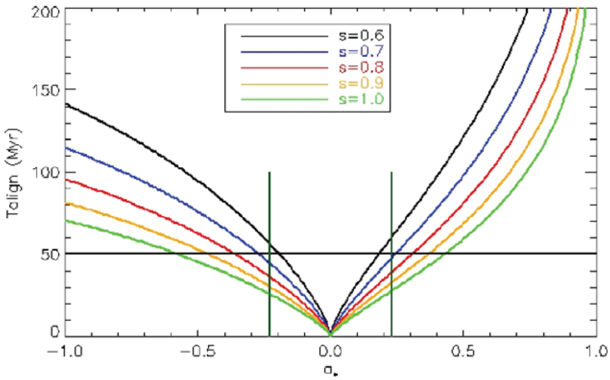

Figure 1. Alignment timescale predicted by the Bardeen-Petterson effect for different values of the exponent of the surface density equation. The dark green line corresponds to the minimum value of the black hole spin given by Daly (2009).

these two regions is known by Bardeen-Petterson radius and its location depends of the accretion disc configuration (Bardeen & Petterson 1975; Kumar & Pringle 1985; Nelson & Papaloizou 2000).

3. Results

Solving the equations for the Bardeen-Petterson effect given by Martin *et al.* (2007) we were able to find the precession period of NGC 1275 and put constrains on the black hole spin and the exponent of the surface density equation. The predicted values from the theory can be seen in the Fig. 1.

4. Conclusions

In this work we were able to explain the precession period found in the numerical simulations. We found that the accretion disk has an exponent of $0.6<s<0.7$ and that the black hole spin has a value of $0.23<a_*<0.4$.

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