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THE PARKER INSTABILITY IN AXISYMMETRIC FILAMENTS: FINAL EQUILIBRIA WITH LONGITUDINAL MAGNETIC FIELD

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RESUMEN

En este trabajo se estudian los estados finales de equilibrio que surgen de la inestabilidad de Parker cuando partimos de una configuración cilíndrica de gas en equilibrio magnetohidrostático en un campo gravitacional radial y con un campo magnético longitudinal. Nuestro objetivo es comparar los estados de equilibrio no lineales con los que se obtienen en los sistemas con geometría Cartesiana. Se presentan los mapas de densidad y de las líneas de campo magnético en ambas geometrías para un campo gravitacional de intensidad constante. Encontramos que el flotamiento magnético es menos eficiente bajo simetría axial que en una atmósfera Cartesiana. Como consecuencia, las condensaciones que se forman en el modelo axisimétrico tienen menor densidad columnar. Por ende, el cociente entre la presión magnética y térmica en el estado final toma valores más extremos bajo simetría Cartesiana. Se discuten también algunos modelos en los que el campo gravitacional no es uniforme.

ABSTRACT

We study the final equilibrium states of the Parker instability arising from an initially unstable cylindrical equilibrium configuration of gas in the presence of a radial gravitational field and a longitudinal magnetic field. The aim of this work is to compare the properties of the nonlinear final equilibria with those found in a system with Cartesian geometry. Maps of the density and magnetic field lines, when the strength of the gravitational field is constant, are given in both geometries. We find that the magnetic buoyancy and the drainage of gas along field lines are less efficient under axial symmetry than in a Cartesian atmosphere. As a consequence, the column density enhancement arising in gas condensations in the axially-symmetric model is smaller than in a Cartesian geometry. The magnetic-to-gas pressure ratio in the final equilibrium state takes more extreme values in the Cartesian model. Models with non-uniform radial gravity are also discussed.

Key Words: instabilities — ISM — ISM: structure — magnetic fields — MHD

1. INTRODUCTION

Parker (1966) demonstrated that a layer supported against the vertical gravity by the pressure of interstellar gas, horizontal magnetic field and cosmic rays is always unstable to long wavelength deformations of the field lines because of the buoyancy of magnetic field and cosmic rays. Much work has been done to understand the role of the Parker instability in modeling the structure of the interstellar medium (ISM) and, more specifically, its role in gathering gas to trigger the formation of giant molecular clouds (e.g., Mouschovias, Shu, & Woodward 1974; Blitz & Shu 1980; Mouschovias, Kunz, & Christie 2009). Giz & Shu (1993), Kim, Hong, & Ryu (1997) and Kim & Hong (1998) examined how the non-uniform nature of the Galactic gravity might affect the length and timescales of the Parker instability. Many studies have been devoted to investigate the effect of other physical ingredients on the Parker instability (Shu 1974; Nakamura, Hanawa, & Nakano 1991; Hanawa, Matsumoto, & Shibata 1992; Hanasz & Lesch 2000; Kim et al. 2000; Santillán et al. 2000; Kim, Ryu, &

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