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VARIABLE JETS WITH NON-TOP HAT EJECTION CROSS SECTIONS: A MODEL FOR THE KNOTS OF THE HH 34 JET

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RESUMEN

Calculamos modelos axisimétricos, con una variación sinusoidal (de un modo) y un perfil de sección recta inicial de velocidad. Encontramos que para cocientes de velocidad borde a centro decrecientes, uno obtiene superficies de trabajo con choques de proa con alas progresivamente más extendidas. Estas alas producen emisión de [S II] que parcialmente llena las regiones entre los nudos en los mapas de emisión predichos. Luego calculamos modelos de 3 modos (con parámetros apropiados para el chorro HH 34), y comparamos los mapas de emisión predichos con imágenes del archivo del HST de HH 34. Encontramos que un modelo con cociente de velocidades borde a centro moderado produce estructuras de nudos con morfologías y variabilidades temporales muy parecidas a las observadas en HH 34.

ABSTRACT

We compute axisymmetric, single-sinusoidal mode variable ejection models with a non-top hat ejection velocity cross section. We find that for decreasing edge-to-center velocity ratios one obtains internal working surfaces with progressively more extended bow shock wings. These wings produce [S II] emission which partially fills in the inter-knot regions in predicted intensity maps. We then compute 3-mode models (with parameters appropriate for the HH 34 jet), and compare predicted intensity maps with archival HST images of HH 34. We find that a model with a moderate edge-to-center velocity ratio produces knot structures with morphologies and time-variabilites with clear similarities to the observations of HH 34.

Key Words: ISM: jets and outflows — ISM: kinematics and dynamics — stars: mass-loss — stars: pre-main sequence

1. INTRODUCTION

Rees (1978) first suggested that a variability in the ejection might be responsible for the structure observed in extragalactic jets. This idea was then pursued numerically by Wilson (1984), who modeled extragalactic jets with "twin-lobe" structures.

Raga et al. (1990) proposed an ejection variability as a mechanism for explaining the chains of knots observed along HH jets such as HH 34 (Reipurth et al. 1986) and HH 111 (Reipurth 1989). This proposed model was strengthened by the fact that later ground-based (Reipurth & Heathcote 1992; Reipurth, Raga, & Heathcote 1992) and HST images (Reipurth et al. 2002, 1997) showed that some of the knots along the HH 34 and HH 111 jets have bow-like morphologies.

This model has been explored analytically (e.g., Cantó, Raga, & D'Alessio 2000) and numerically (e.g., De Colle, Raga, & Esquivel 2008). Different effects in variable ejection jets have been studied, such as:

- different forms of the ejection variability (Hartigan & Raymond 1993; Tesileanu et al. 2009),
- the added presence of a precession (Raga & Biro 1993; Smith & Rosen 2005),
- variable jets with magnetic fields (Gardiner & Frank 2000; De Colle et al. 2008),
- variable jets in a sidewind (Esquivel et al. 2009).

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