Journal of Physics: Conference Series **728** (2016) 072009 doi:10.1088/1742-6596/728/7/072009

Coaxial rings and H_2 knots in Hubble 12

Chih-Hao Hsia[1,2], Sun Kwok[1], Wayne Chau[1,2] and Yong Zhang[1,2]

[1] Laboratory for Space Research, Faculty of Science, The University of Hong Kong, Hong Kong, China

[2] Department of Physics, The University of Hong Kong, Hong Kong, China

E-mail: [1,2] xiazh@hku.hk

Abstract. Hubble 12 (Hb 12) is a young planetary nebula (PN) exhibiting nested shells. We present new near-infrared narrow-band imaging observations of Hb 12 using the Canada-France-Hawaii Telescope (CFHT). A number of co-axial rings aligned with the bipolar lobes and two pairs of separate H_2 knots with different orientations are detected.

1. Introduction

Morphological transformation from spherical geometry to bipolar is believed to occur shortly after the asymptotic giant branch (AGB). Recent near-infrared observations in the H_2 2.122 μm line [1] have shown that molecular gas is widely observable in PNs, providing us important information about the mass-loss history during AGB and shaping mechanism of PNs. A few hourglass PNs (e.g. MyCn 18, M 2-9, and Hen 2-104) are discovered to have high-speed collimated outflows [2], which could be produced through binary interactions. In this paper, we study a young PN Hubble 12 (Hb 12) with the goal of determining its molecular gas structures and properties of the central source.

2. Observations and Results

Deep near-infrared images of Hb 12 were taken using the Wide-field InfraRed Camera (WIRCam) on the *Canada-France-Hawaii Telescope* (CFHT). The nebula was imaged with three narrow band filters: H_2 (λ_c = 2.122 μm), Brγ (λ_c = 2.166 μm), and K continuum (Kc; λ_c = 2.218 μm). The H_2 *CFHT* image of Hb 12 is shown in Figure 1. Three pairs of bipolar lobes and a number of co-axial rings aligned with the outermost lobe can be seen in the image. The nested structures may have a common formation mechanism, most likely involving mass-loss processes influenced by a binary core [2]. These rings are thought to be the manifestation of a time-variable, collimated fast wind of bipolar lobes interacting with surrounding AGB medium. Moreover, two pairs of separate H_2 knots with different position angles (N1-S1: 175°±2° and N2-S1: 171°±2°) are found in the wide-field H_2 *CFHT* image (Figure 2). The pair of knots N1-S1 has a projected length of $\sim$ 133 arcsec and N2-S2 has a projected size of $\sim$ 353 arcsec, respectively. This could be related to the binary nature of the nucleus of Hb 12 [3], and the formation of bipolar, rotating, episodic jet. A bipolar precessing jet model for these knots is needed to better understand their nature.

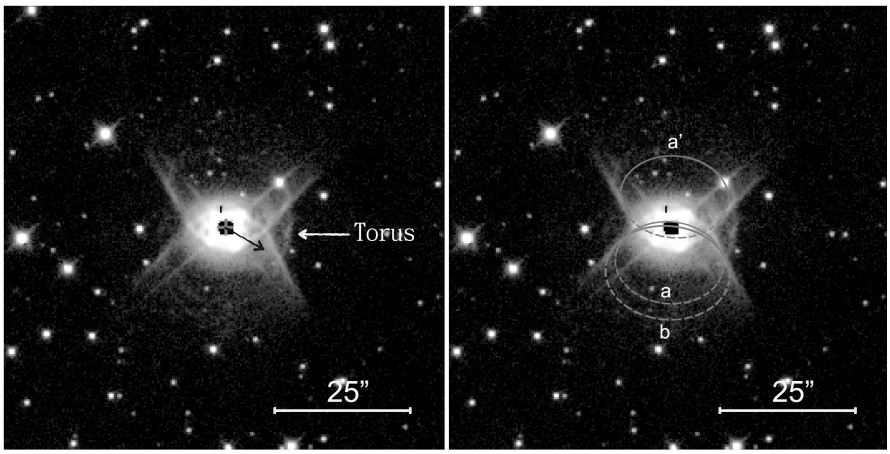

Figure 1. CFHT WIRCam H_2 image of Hb 12. (Left) Black arrow at the central part represent the direction of proper motion. (Right) This panel is the same with the left panel but with schematic outlines of three coaxial rings with inclination angle of 45° in outer lobes of Hb 12.

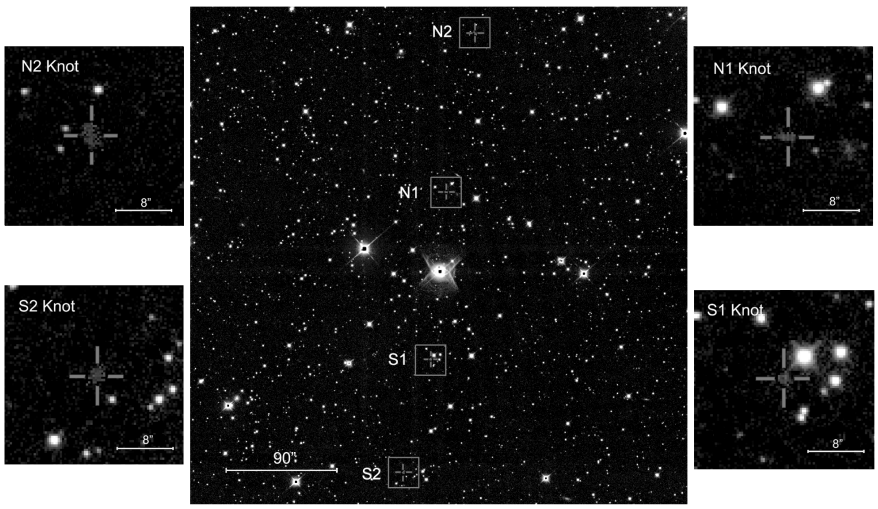

Figure 2. A wide-field CFHT H_2 image of Hb 12, whose central part is the same as Figure 1. The upper right, upper left, lower right, and lower left insets indicate the positions of N1, N2, S1, and S2 knots, respectively. The knots N1 and S1 might be the H_2 counterparts of the knots seen at [NII] [4].

Acknowledgments

Financial support for this work was provided by the Research Grants Council of the Hong Kong Special Administrative Region, Project no. HKU 7031/10P and HKU 7062/13P.

References

[1] Guerrero M A, Villiaver E, Manchado A, Garcia-Lario P and Prada F 2000 *Astrophys. J. Suppl. Series* **127** 125
[2] Corradi R L M, Livio M, Balick B, Munari U and Schwarz H E 2001 *Astrophys. J.* **553** 211
[3] Hsia C H, Ip W H and Li J Z 2006 *Astron. J.* **131** 3040
[4] Vaytet N M H, Rushton A P, Lloyd M, López J A, Meaburn J, O'Brien T J, Mitchell D L and Pollacco D 2009 *Mon. Not. R. Astron. Soc.* **398** 385