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On the Bowshocks Associated with the Orion Proplyds

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Abstract. We investigate the global stellar wind dynamics of the exciting star of the Orion Nebula by using the "proplyds" and their bowshocks as probes of the ram pressure balance conditions in the nebula. This careful analysis is only possible if high resolution data are available, since the proplyds are so small and the bowshocks are so faint.

1. Introduction

The "proplyds" are bright, compact, emission-line knots surrounding low-mass stars in the Orion Nebula (O'Dell 1998). An explanation for these objects is that the radiation from the main exciting source in the nebula, θ^1 C Ori, is photoevaporating the circumstellar material around these low-mass stars (Johnstone, Hollenbach, & Bally 1998; Henney & Arthur 1998). This photoevaporated flow then interacts with the stellar wind from θ^1 C Ori. The interaction should produce a bowshock around the proplyd (García-Arredondo, Arthur, & Henney 2000), and indeed, such bowshocks can be seen in HST images of the Orion Nebula (Bally et al. 1998).

The faint high-ionization arcs of emission, interpreted as bowshocks, are offset by 1–4 arcsec from the proplyds in the direction of the ionizing star, θ^1 C Ori, (see Fig. 1). These bowshocks result from the collision between the transonic photoevaporating flow (~ 20 km s^{-1}) from the proplyd and the highly supersonic stellar wind (1000 km s^{-1}) from θ^1 C Ori.

2. Ram Pressure Balance

The ram pressure of the proplyd photoevaporating flow at the bowshock should balance the ram pressure of the fast wind from θ^1 C Ori. In Figure 1 we plot the proplyd wind ram pressure against projected distance for a sample of proplyds (diamonds). On the same graph we plot the fast stellar wind ram pressure at the same projected position (lines). The required proplyd parameters (wind density, velocity, inclination angle) have been taken from the models fit to HST observations by Henney & Arthur (1998). The bowshocks of the inner group of proplyds (filled diamonds) are consistent with this but the two outer proplyds

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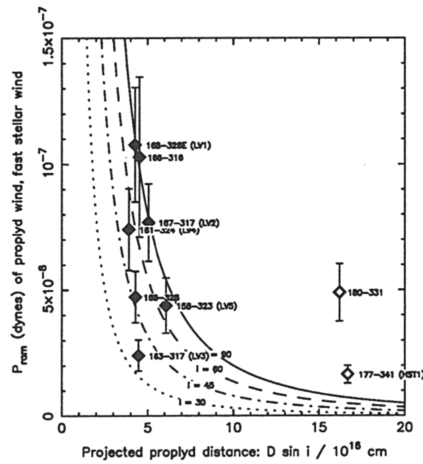

Figure 1. Left: Faint [O III] emission arc in front of a proplyd in the Orion nebula. Right: Ram pressure of a sample of proplyd winds (diamonds) and the θ^1 C Ori fast stellar wind ram pressure (lines) against distance for four different inclination angles.

(hollow diamonds), have proplyd flow ram pressures at the bowshock significantly higher than the fast wind ram pressure expected at their positions. If the fast wind passed through a global inner shock before reaching these proplyds, then they would lie in the hot subsonic wind bubble, whose thermal pressure would be roughly constant and equal to the ram pressure at the position of the inner shock. In this case, the ram pressure of the proplyd wind is balanced by the combined thermal plus ram pressure of the shocked stellar wind.

3. Final Remarks

We performed numerical simulations of both the supersonic and subsonic stellar wind–proplyd wind interactions. Our results are in excellent agreement with the observations (García-Arredondo, Henney, & Arthur in preparation). For the subsonic case, the simulation using the parameters of the proplyd 177–341 is consistent with a global stellar wind shock position of 1.08×10^{17} cm (0.035 parsec) from the star θ^1 C Ori.

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