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INSTABILITIES IN HOT STAR WINDS

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We present work investigating the stability of line-driven winds using a non-Sobolev approach. We find that the dense shell structures that characterize the growth of radiation-driven instabilities in one-dimensional simulations break up into numerous bow-shaped clumps in two dimensions.

The base of a stellar wind is not uniformly smooth, as fluctuations in the properties of the stellar surface layers arise from a variety of effects. Therefore, a realistic model should account for the effect of perturbations to the mean flow.

Owocki, Castor, & Rybicki (1988) propose a pure absorption model that dispenses with the Sobolev (large velocity gradient) approximation, using a resolved line profile function. The acceleration of the wind is determined by an explicit calculation of the optical depth for a statistical ensemble of line opacities. This model accurately reproduces the qualitative features of more complete treatments of the unstable line-driven flows in one dimension. We have therefore adopted this model for these initial investigations of the flow structure in two dimensions.

We have used a top-hat line-profile function in order to accelerate the line force calculation. As the absorption by gas within a single computational cell is localized in frequency, only a small range of frequency bins need be included in the calculation of the radiation force on the cell and the change in the transmitted spectrum. This local approach allows the computational expense to be greatly reduced (important for multidimensional simulations).

In one dimension, we find results similar to Owocki et al. (1988). Using a smooth CAK (Castor, Abbott, & Klein 1975) flow as the initial condition, we find that dense shells arise from the growth of small numerical fluctuations at the wind base. When a finite perturbation is applied to the initial flow (in either density or velocity), it grows into a rarefaction wave leading to a plane reverse shock. Eventually, the shock becomes unstable and sends dense lumps into the trailing rarefaction. Once these structures have left the grid, the flow returns to a structure similar to that in the unperturbed case.

REFERENCES