Effect of scattering on the transonic solution topology and intrinsic variability of line-driven stellar winds

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For line-driven winds from hot, luminous OB stars, we examine the subtle but important role of diffuse, scattered radiation in determining both the topology of steady-state solutions and intrinsic variability in the transonic wind base. We use a smooth source function formalism to obtain nonlocal, integral expressions for the direct and diffuse components of the line-force that account for deviations from the usual localized, Sobolev forms. As the scattering source function is reduced, we find the solution topology in the transonic region transitions from X-type, with a unique wind solution, to a nodal type, characterized by a degenerate family of solutions.

Specifically, in the idealized case of an optically thin source function and a uniformly bright stellar disk, the unique X-type solution proves to be a stable attractor to which time-dependent numerical radiation-hydrodynamical simulations relax. But in models where the scattering strength is only modestly reduced, the topology instead turns nodal, with the associated solution degeneracy now manifest by intrinsic structure and variability that persist down to the photospheric wind base. This highlights the potentially crucial role of diffuse radiation for the dynamics and variability of line driven winds, and seriously challenges the use of Sobolev theory in the transonic wind region. Since such Sobolev-based models are commonly used in broad applications like stellar evolution and feedback, this prompts development of new wind models, not only for further quantifying the intrinsic variability found here, but also for computing new theoretical predictions of global properties like velocity laws and mass-loss rates.

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