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Hydrodynamical Modeling of Stellar Wind Bubbles for Improved Photoionization Analysis

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We present the first steps of a new approach aimed at improving photoionization analysis in dwarf galaxies by replacing unresolved features in chemodynamical simulations (Recchi and Hensler 2013) with physically consistent structures from hydrodynamical modeling. In previous works (Melekh et al. 2015, 2024), artificial thin dense shells (TDS) were introduced to emulate shock fronts that could not be resolved in chemodynamical simulations. To overcome this limitation, we initiated a transition to hydrodynamical simulations using the PLUTO code (Mignone et al. 2007), beginning with a 1D spherically symmetric model of a stellar wind from a single massive star. This setup reproduces the classical structure of a wind-blown bubble as described by Castor, McCray, and Weaver (1975, 1977), including the central hot shocked wind, the contact discontinuity, and the dense swept-up shell. Our results confirm the formation of these regions, including the TDS, and allow direct comparison with theoretical models of bubble evolution, validating the numerical approach. This structure serves as a foundation for subsequent photoionization modeling. The ultimate goal is to incorporate these hydrodynamic profiles into multi-component photoionization simulations to achieve more self-consistent results. This work sets the stage for extending the method to multi-dimensional simulations and full galaxy-scale outflows.

Primary author: Mr POZDIEIEV, Andrii (Ivan Franko National University of Lviv)

Co-author: Dr MELEKH, Bohdan (Ivan Franko National University of Lviv)

Presenter: Mr POZDIEIEV, Andrii (Ivan Franko National University of Lviv)

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