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Challenges in Radiative Transfer Modeling - W3 IRS5

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Analysis and Results

Our analysis consists of modeling the spectral energy distribution (SED) produced by the W3 IRS5 system. An SED is a plot of luminous flux (energy) as a function of wavelength. This energy is in the units of Janskys (Jy), where 1 Jy equals $10^{-26}$ Wm$^{-2}$Hz$^{-1}$. In this investigation we are only concerned with the infrared-submillimeter spectrum, ranging from approximately 1 to 1000 microns.

Using a 2D Monte Carlo modeling code developed by Barbara Whitney (Whitney et al. 2003), we modeled our source as a star with a circumstellar disk and bipolar cavity enclosed within an overlying envelope. This technique is an improvement over past methods of 1D spherically symmetric modeling, where adding disk or cavity components was not possible.

Models were fit to data collected by Professor Campbell and collaborators on the KAO and at the IRTF, in addition to photometric data found in current astronomical literature (Campbell et al. 1995). We present here the best-fit model to date in an ongoing modeling effort. System parameters used for this model are listed in Table I. In the process of fitting the model, the angle of the cavity opening had a great effect on the shape of the resulting SED, while disk parameters (mass and radius) were not strong constraints. The best-fit SED given here is not only a function of the input parameters, but also a function of viewing angle of the observer. Due to the non-uniformity of the system geometry, different viewing angles yield different SEDs, as represented by the different colored plots, each representing a specific angle.

We believe that our model still offers valuable if approximate information about the overall system. We approximate the multiple protostars as a single source within a shared outer envelope, which seems reasonable due to their close proximity. In addition, Inai et al. (2000) concludes that outflows from the multiple sources align in a single direction, providing a logical argument for approximating the system as having a composite bipolar outflow cavity. While detailed information about the individual sources is not possible to derive from our models, obtaining general parameters of the overall system is still within the realm of possible outcomes.

Acknowledgements

I would like to thank Murray Campbell for all his help and guidance throughout this project. I would also like to thank Ryland Brooks for his partnership on the project and Dr. John Kuehne for his computer support at Colby College.

W3 IRS5 Complexities

Though the 2D Monte Carlo code uses a simple single source model, this in fact is not the case for W3 IRS5. Howell et al. (1981) and Neugebauer et al. (1982) resolved the system into a binary infrared source. Furthermore, Megnath et al. (2006) detected three additional infrared sources, opening the possibility that this system is an early trapezium system embedded in its natal gas cloud. This multiplicity of sources creates a modeling nightmare, in which the complexities are too great for any non-specialized modeling code to handle.

FIG 1. - A Hubble Space Telescope image of HH30 showing a genuine disk and jet system. Also, a simple diagram of the geometry expected from a protostellar system according to the theory of accretion-based formation.

FIG 2. - The SED of our best-fit 2-D radiative transfer model. Parameters for this model are given in Table I.

The object of interest for our analysis is the W3 IRS5 high-mass star formation region. W3 IRS5 is the nearest region of high-mass star formation after the Orion Nebula, at a distance of 1.83 ± 0.14 kpc (Imai et al. 2000). This region has been thoroughly studied due to its proximity and because of its brightness, with a luminosity of $1.45 	imes 10^4$ L$_\odot$ at 1.83 kpc (Campbell et al. 1995). Professor Campbell and collaborators conducted observations of this region utilizing both the Kuiper Airborne Observatory (KAO) in 1987 and 1989 (Campbell et al. 1995) and the Infrared Telescope Facility (IRTF) atop Mauna Kea in 2002 (see poster by R. Brooks).

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