*IAU Colloquium 190 on Magnetic Cataclysmic Variables*
*ASP Conference Series, Vol. 315, 2004*
*Sonja Vrielmann & Mark Cropper, eds.*

# Computational Models of the Accretion Stream in Polars

Jennifer L. Cash

*South Carolina State University, Physical Sciences Department., P.O. Box 7024, Orangeburg, SC 29117, USA*

**Abstract.** I present the current results of my computational modeling of the accretion stream in polars. These numerical stream models, generated using an SPH code, yield a 3-dimensional map of the gas distribution throughout the stream, including the distribution of material as it impacts the white dwarf surface. The major features of the accretion streams generated by the model code are presented as well as results of a model representing EF Eri. The prospective future development of the model is also discussed.

In polars, also known as AM Her systems, the strong magnetic field of the white dwarf diverts the accreting gas stream out of the orbital plane along magnetic field lines directly onto the white dwarf surface. While our basic understanding of the accretion process in polars is well established, the detailed modeling of the magnetic interaction and the stream structure remains a complex problem.

My research seeks to study the accretion stream in polars through the use of computationally intensive models, which eliminate many of the simplifying assumptions adopted to tackle these systems in the past. The numerical method used in my modeling is smoothed particle hydrodynamics or SPH. An overview of the method and initial results is given in Cash & Howell (2002) and Cash (2002) provides a comprehensive discussion of the initial work.

The SPH model accretion streams have two main regions, the ballistic stream and the magnetically confined material. The initial results indicate that the SPH particles couple to the magnetic field lines such that two magnetically controlled paths form, and an "L1 path" where material coupled to the field lines immediately and a "main path" where material couples after flowing along the ballistic path for some distance. The amount of material that was predicted to couple directly at L1 depended greatly on the mass transfer rate as well as the assumptions used to determine the coupling condition.

Another main feature of the SPH model streams is the extended and asymmetric coupling region leading to an impact region on the white dwarf which contains considerable asymmetry. The accretion region is an arc which has a much higher accretion rate on one end. If the stream has a significant amount of material coupling at L1, then a second separated accretion region forms where that material is channeled onto the white dwarf surface. A through discussion of these features is given in Cash (2002) and the forthcoming Cash & Howell (2003).

One polar investigated with the SPH models is EF Eri. By considering models of EF Eri over a large range of mass transfer rates, we were able to determine that it is likely that a large portion of the accreting material couples to the magnetic field at or near the L1 point. New phasing information from Harrison et al. (2003) puts the high state eclipse dip near phase zero, providing possible evidence that a dense magnetically controlled stream comes from very near the L1 point.

Now that the initial models development is complete, we are working on improving them. The future development of the SPH models will proceed in two directions, the adaptation of the models for comparison to observations and improvements to the theoretical treatment of the magnetic forces in the code. Each direction of development is discussed separately below.

The model code can easily be adapted to provide useful information for comparison to observations. The SPH models predict the density and velocity of the accretion mass as a function of position. With an estimation of the inclination of the system, the 3-D velocity information can be translated into the radial velocity at any point along the stream as a function of phase. This information can then be used to interpret trailed spectra and Doppler tomograms of polars. The density distribution provided by the SPH models can be used for eclipsing systems to determine the viewing anlge onto the system geometry as a function of phase and predict how the gas in the accretion stream blocks emission from the white dwarf and accretion region. The combination of the SPH models, radial velocity observations, and eclipse light curves can then be used to determine the emission distribution in the binary system.

Other future plans for the model development include improving the handling of the magnetic forces on the ballistic stream and an investigation of the possible effects the magnetic field has on the accretion stream. The initial SPH models were developed with a simple abrupt coupling, but the SPH code has enough flexibility to examine other treatments. By developing models using several of the common treatments of the magnetic forces, such as the abrupt coupling conditions, a magnetic drag force, or a magnetic pressure gradient term in the force equations, we hope to determine the best way to model the magnetic accretion streams.

**Acknowledgments.** This work was supported in part by funding to South Carolina State University from NASA/MU-SPIN NCC 5-534, NASA/OSS NAG 5-10145 and NASA/URC NCCW-0085.

## References

Cash, J. & Howell, S. 2003, in preparation

Cash, J. & Howell, S. 2002, in ASP Conf. Ser. Vol. 261, The Physics of Cataclysmic Variables and Related Objects, ed. B.T. Gänsicke, K. Beuermann & K. Reinsch (San Francisco: ASP), 141

Cash, J. 2002, PhD Thesis, University of Wyoming

Harrison, T., Howell, S., Huber, M., Osborne, H., Holtzman, J., Cash, J. & Gelino, D. 2003, AJ, in revision