Final report
“TJ-CompTON”, PERG05-GA-2009-249164

Star formation is among the most actively research fields in astrophysics, not only because it deepens the understanding of the physical mechanisms involved, but also because it provides the answers concerning the origins of our own solar system. On the other hand, the exact same equations that describe the dynamics of magnetized plasmas during the birth of stars, describe also the laboratory plasmas on earth. Taming the latter is the key to fusion, a process that will give access to an almost infinite and cheap source of energy.

Young Stellar Objects (YSO) consist of two parts, a central object that will become a star, and a surrounding disk, the remnants of which will form its planets. Such systems are associated with two complex and interrelated phenomena, disk accretion and mass outflows. In this project we have addressed some of the open questions related to jets, a critical phenomenon to understand how stars, like our sun, are formed. In particular, protostellar jets are supersonic and highly collimated mass outflows that propagate to large distances. Recent observational data as well as theoretical arguments support a two-component jet scenario, wherein a magneto-centrifugally accelerated disk wind, required to explain the high mass loss rates, surrounds and collimates a pressure driven stellar outflow. Adopting a theoretical approach, we have performed and analyzed magneto-hydrodynamical (MHD) numerical simulations of YSO jets. Specifically, we have focused on bridging the gap between the theoretical models of two-component YSO outflows with observations of protostellar jets. On the one hand, we have addressed some of the peculiar dynamical properties that some observed systems demonstrate, such as the velocity asymmetries between the red- and blue-shifted bipolar flows (Matsakos et al. 2012) and the counter-rotation of some jets (Sauty et al. 2012). On the other hand, we have studied the effects of radiation cooling effects in the time-dependent structure of the outflows (Matsakos et al. in preparation) and we have generated synthetic emission maps to directly compare with observations (Tesileanu et al. in preparation).

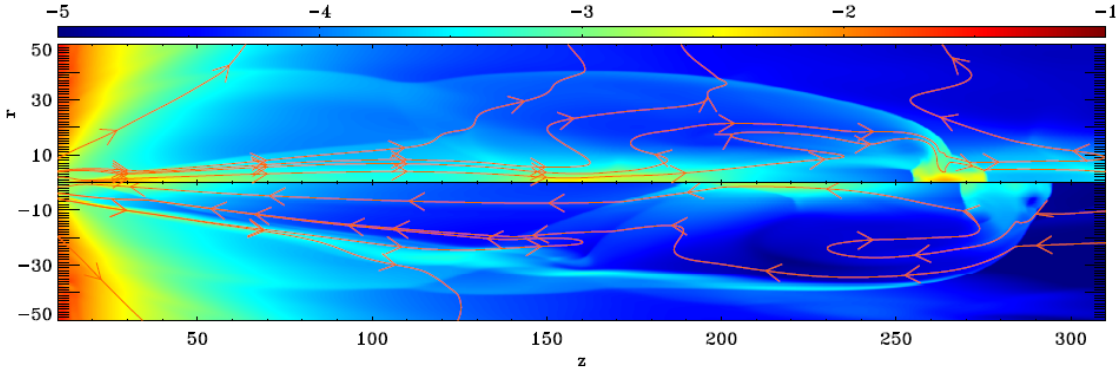

Figure 1: Asymmetric jet evolution between the two YSO hemispheres, as seen side by side in the upper and bottom panel (Matsakos et al. 2012).

Bibliography

1. Matsakos, T., Vlahakis, N., Tsinganos, K., et al. 2010, ASPCS, Vol 424
2. Matsakos, T., Vlahakis, N., Tsinganos, K., Karampelas, K., Sauty, C., et al. 2012, A&A, 545, 53
3. Sauty, C., Cayatte, V., Lima, J. J. G., Matsakos, T., & Tsinganos, K. 2012, ApJ, 759, L1

4. Matsakos, T., Te¸sileanu, O., Mignone, A., et al. in preparation
5. Tesileanu, O., Matsakos, T., Mignone, A., et al. in preparation
6. Tzeferacos, P., Mignone, A., & Matsakos, T., in preparation

Dissemination activities

The results of this work have been presented by giving a talk at the 9th International Conference of the Hellenic Astronomical Society as well as in written form in the proceedings of the same conference (Matsakos, T., Vlahakis, N., Tsinganos, K., et al. 2010, ASPCS, Vol 424, edited by Tsinganos, K., Hatzidimitriou, D., Matsakos, T.). Moreover, the researcher has been invited twice to give a seminar on the topic, once at the National Observatory of Athens, Greece, and once at the Service d'Astrophysique, IRFU/CEA, France.

The researcher has provided his previously acquired numerical expertise to help several PhD and post-graduate students at IASA and the University of Athens. He introduced two post-graduate students to the numerical treatment of the MHD equations and guided them to perform YSO jet simulations as a part of their dissertations. In particular, the work done by one of those (Kostas Karampelas) has contributed to the results of a published paper (Matsakos et al. 2012). In addition, the researcher has helped with the discretization and solution of differential equations on wind driven mass loss and magnetic braking problems, a contribution that has been acknowledged in the published paper of Nanouris et al. (2011).

Career development of the researcher

The research activities as well as the expertise obtained on this scientific topic and the numerical methods, has further developed the skills and competences of the researcher, building a strong background for his career. In addition, the researcher was given the opportunity to co-edit the proceedings of the 9th International Conference of the Hellenic Astronomical Society: "Advances in Hellenic Astronomy during the IYA09" (Tsinganos, Hatzidimitriou & Matsakos 2010). In that volume 114 papers were presented, which not only did they familiarize him with a variety of astrophysical topics, but also developed his organizational and public outreach skills.

Development of lasting co-operation with the scientific and/or industrial environment of the country from which he/she has moved

The collaboration with O. Tesileanu (University of Bucharest) on the application of radiation cooling and emission map generation, as well as the rest of the Turin group on the two-component jet simulations and PLUTO related projects (S. Massaglia, E. Trussoni, A. Mignone, P. Tzeferacos) demonstrates the lasting collaboration that has been developed with the previous host country of the Marie Curie Fellowship. The collaboration is ongoing, with several new projects already in progress. In particular, the researcher has visited several times Turin and he has been invited to present the results of this work at a scientific meeting organized in March 2013.

Project Management

The project was managed successfully in Athens by prof. Kanaris Tsinganos and the staff of the Institute of Accelerating Systems and Applications (IASA) which is affiliated to the University of Athens. The Institute (IASA) provided the Researcher with all requirements for a successful implementation of the present grant, i.e.: excellent office space, modern computers, full logistical support for the grant and all needed accommodation during the period of the grant.