Usage Report for Fiscal Year 2015

Project Title:

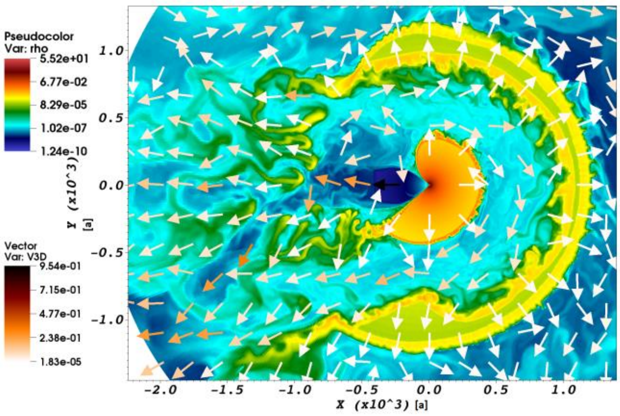
Gamma Ray Bust Central Engine in 3D

Name: Maxim Barkov

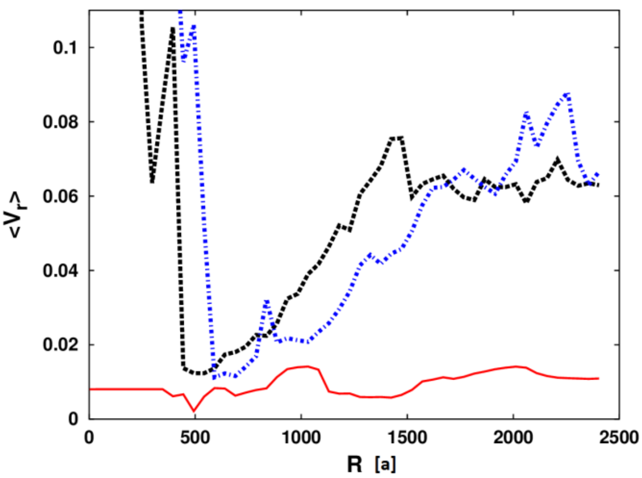
Laboratory at RIKEN: Astrophysical Big Bang

A mysterious X-ray-emitting object has been detected moving away from the high-mass gamma-ray binary PSR B1259-63, which contains a non-accreting pulsar and a Be star whose winds collide forming a complex interaction structure. Given the strong eccentricity of this binary, the interaction structure should be strongly anisotropic, which together with the complex evolution of the shocked winds, could explain the origin of the observed moving X-ray feature. We propose here that a fast outflow made of a pulsar-stellar wind mixture is always present moving away from the binary in the appoastron direction, with the injection of stellar wind occurring at orbital phases close to periastron passage. This outflow periodically loaded with stellar wind would move with a high speed, and likely host non-thermal activity due to shocks, on scales similar to those of the observed moving X-ray object. Such an outflow is thus a very good candidate to explain this X-ray feature. This, if confirmed, would imply pulsar-to-stellar wind thrust ratios of 0.1, and the presence of a jet-like structure on the larger scales, up to its termination in the ISM.

We use public code PLUTO to perform restricted in theta direction 3D hydro simulation. The computational domain has a size r = [2a; 2500a], $\vartheta = [1/4\pi; 3/4\pi]$, and $\varphi = [0; 2\pi]$, with resolution $[N_r; N_\vartheta; N_\varphi]$ = [1152; 3; 768]. We are modelling interaction scales larger than the Oe-type star decretion disc. Since the mass associated to this disc is few orders of magnitude smaller than that of the stellar wind expelled during torb, the presence of the stellar disc has been neglected here, and the stellar wind is assumed to have spherical symmetry. The two-wind thrust ratio was fixed to eta = 0.1, the stellar wind speed to v_w = 0:008 c, the gas adiabatic index to $gamma_{ad}$ = 4/3, the pulsar wind Lorentz factor to Gamma = 3, the orbital period to t_{orb} = 1237 days, the eccentricity to e = 0.87, and masses of the stars to $30M_{sun}$ and $1.44M_{sun}$ for the normal star and the pulsar, respectively, which together with t_{orb} imply a = 10^{14} cm. The periastron and apastron pulsar locations are to the right and to the left from the point (0; 0), respectively.



Distribution by colour of density (top panel) and arrows representing the ow motion direction, in the orbital plane (XY, in a units) for PSR B1259-63 system after 2500 days (680 days after last periastron passage).



Averaged radial velocity (< Vr >) with distance from the binary for sector Sp and t = 2514 days (692 days after periastron) (red solid line), and for sector Sa and t = 2389 days (567 after periastron passage) (black-dashed line) and t = 2514 days (692 days after periastron passage) (blue dot-dashed line).

Presented approach can be applicable for other gamma-ray loud galactic binaries what we plan to do in the next FY.

Usage Report for Fiscal Year 2015

Fiscal Year 2015 List of Publications Resulting from the Use of the supercomputer

[Publication]

The origin of the X-ray-emitting object moving away from PSR B1259-63;

Barkov Maxim V., Bosch-Ramon Valentí;

Monthly Notices of the Royal Astronomical Society: Letters, Volume 456, Issue 1, p.L64-L68 (2015)

[Others (Press release, Science lecture for the public)]

Gamma ray compact star binaries

Barkov Maxim

Comprehensive Studies of Neutron Stars (RIKEN symposium)

2015/11/24