STSM 2016 RESEARCH PROJECT REPORT

Project title: **Development of the propeller effect model**

Host institution: **Anton Pannekoek Institute for Astronomy (API, Amsterdam, The Netherlands)**

Host: **Dr. Alexander Mushtukov**

Dates: **October 5-22, 2016**

Purpose of the STSM

The centrifugal inhibition of the accretion (aka "propeller effect"; Illarionov & Sunyaev 1975) is one of the most direct evidence of the ultra-strong magnetic field presented in the vicinity of the neutron star. Whereas a schematic description of this effect was presented ~ 30 years ago, the detailed understanding is still missing. The main purpose of the STSM was to study the interplay between the propeller effect and the accretion disc instability arising due to partial ionization of the hydrogen (so called thermal-viscosity instability; Lasota 1997).

Work carried out during the STSM and preliminary results

Ionization state of plasma in the disc determines the opacity and gas equation of state, and, therefore, $\alpha-$viscosity (see e.g. the review by Lasota 2001). In the case of cold state with mainly atomic hydrogen and low viscosity the accreted matter is accumulated in the disc. In the hot state all the hydrogen is mainly ionized and viscosity is high, which allow all the accumulated matter to be rapidly accreted on the central object (white dwarf in the case of dwarf nova). The boundary local effective temperature separating these two states is ~ 6500 K. The cold to hot state transition is triggered by a heating wave propagating through the disc originating either from its inner or outer part (Smak 1984). At the same time the accretion process becomes stable again if the temperature is below the critical value over the entire disc, i.e. in the case of the low mass accretion rate (Lasota 1997).

In our recent work (Tsygankov et al. 2016) we showed that in the case of accreting X-ray pulsars 4U 0115+63 and V 0332+53 the observation of transition of the accretion disc to the cold state is impossible due to propeller regime onset at much higher mass accretion rates than needed to reach 6500 K temperature at the inner radius of the accretion disc. At the same time the overall shape and energetics of the outburst was shown to correspond to the expectation from the disc instability model.

During this STSM we showed that there is a region in the NS parameters space (pulse period, magnetic field strength) exists resulting in the transition of the accretion disc to the cold state before the propeller regime onset. Using these results we are now able to explain some puzzling properties of slowly rotating X-ray pulsars.

Future collaboration with the host institution and foreseen publications

The collaboration with my host Dr. Alexander Mushtukov is well established and resulted in a few highly cited publications in the field of accretion on to the neutron stars. The results of our current research will be submitted to the journal by the end of this year. In addition to the main project another collaboration with the group of Dr. Rudy Wijnands from the same institute was established aimed at the study of the cooling of the neutron stars with strong magnetic fields.

References

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