# Modelling of vertical structure of accretion discs around neutron stars and black holes

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Bursts in X-ray binaries are associated with instability in an accretion disk around a compact object (neutron star or black hole). To examine the stability of the disc, it is necessary to obtain the dependences between the physical parameters (for example, the pressure and energy flux) in the disk. These dependences are found from the solution of the equations of the vertical structure of the disc (Shakura et al. 2018):

$$\frac{1}{\rho}\frac{dP}{dz} = -\omega_{\rm K}^2\, z = -\frac{GM}{r^3} z, \tag{1}$$

$$\frac{d\Sigma}{dz} = -2\rho, \tag{2}$$

$$\frac{\mathrm{d}\ln T}{\mathrm{d}\ln P} \equiv \nabla = \begin{cases} \nabla_{\rm rad},\ \nabla_{\rm rad} < \nabla_{\rm ad}, \\ \nabla_{\rm conv},\ \nabla_{\rm rad} > \nabla_{\rm ad}, \end{cases} \tag{3}$$

$$\frac{dQ}{dz} = \frac{3}{2}\,\omega_{\rm K}\, w_{r\varphi} = \frac{3}{2}\,\omega_{\rm K}\alpha P, \tag{4}$$

$$z \in [0, z_0].$$

Here (1) is the equation of hydrostatic equilibrium, (2) is the equation for mass coordinate, (3) is the equation for temperature gradient (convective of radiative), (4) is the equation of viscous heating (Shakura & Sunyaev (1973) $\alpha$-prescription of viscosity is used). Equations are supplemented by the equation of state and opacity law. System has one free parameter $z_0$, half-thickness of the disc.

Python 3 code is developed to solve system (1–4) numerically. Code allows us to change the equation of state, opacity law and chemical composition, including tabular values from MESA (Paxton et al. 2011). Our calculations can improve the accuracy of the modelling of X-ray binary outbursts. Code is open-source (https://github.com/Andrey890/Vertical-structure-of-accretion-discs).

# Bibliography

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