PLUTO lectures & non-dipolar stellar fields

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with

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Outline

- Lectures “Introduction to PLUTO code”

- Work with CAMK PhD students

- Summer students 2021, work with PLUTO:
  – thin accretion disk around a black hole PLUTO
  – thick SANE disk simulations with PLUTO
  – magnetospheric star-disk interaction with non-dipolar stellar fields

- Meetings, grants, publications

Lectures “Introduction to PLUTO code”

I prepared lectures to introduce students to simulations-from scratch. PLUTO is well documented and public, it is a good starting point.

In 5x2 hrs lectures, a student is brought to active working with PLUTO.

Miki's lectures on Numeric

web.tiara.sinica.edu.tw/~miki/mikipluto.html

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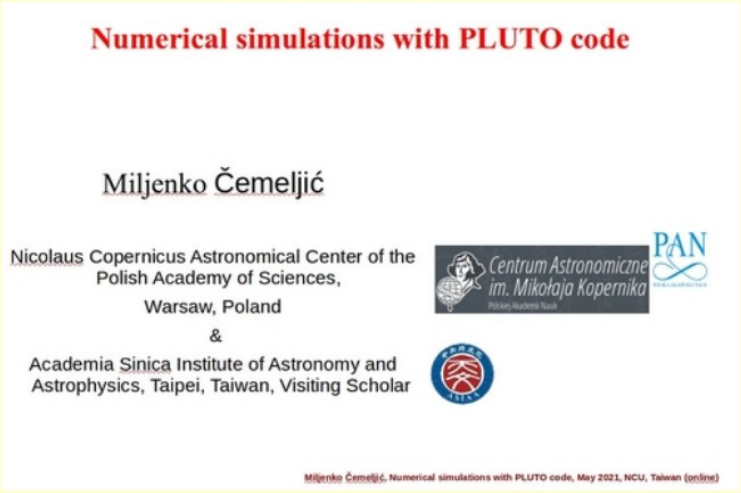
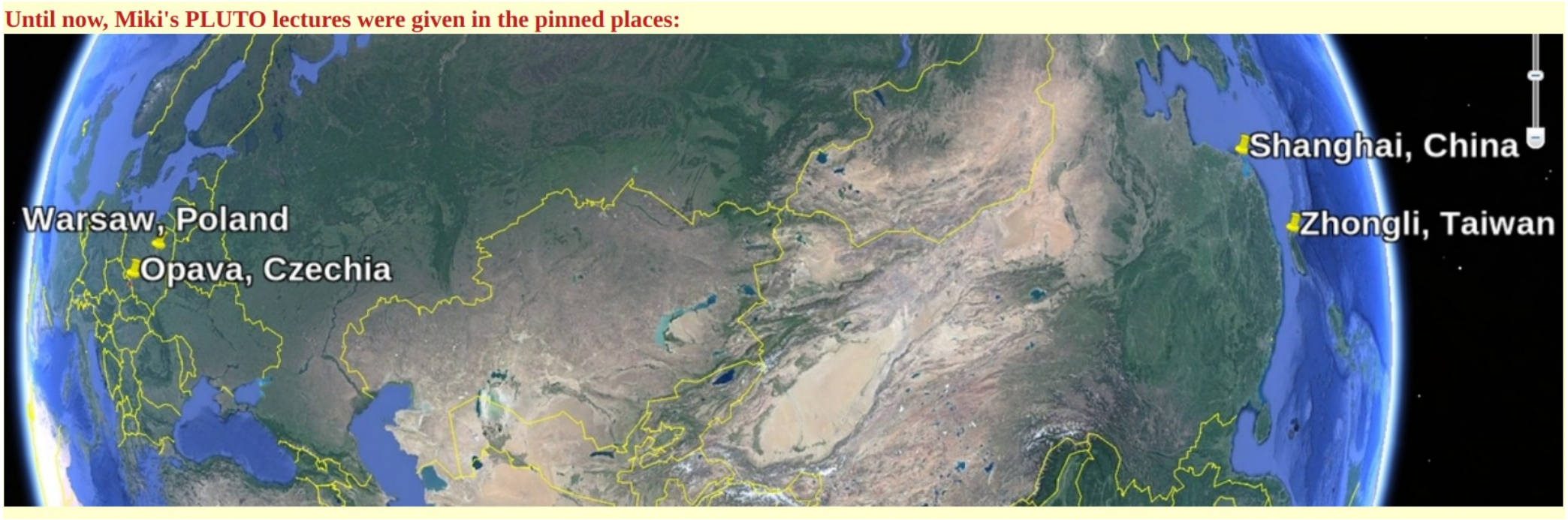
Miki's lectures: Numerical simulations with PLUTO code



**Abstract: Aim of the lectures is to guide attendants to active using of the PLUTO code.
We will work in 5x2 hrs blocks: each hour of theoretical exposition will be followed by an hour of hands-on work with the code.
We will start with a brief introduction to numerical simulations in astrophysics and the position of the PLUTO code with respect to other codes. After a short description of numerical methods employed in the code, we will proceed with the code installation, testing of the installation and initial visualization of the results with gnuplot.
Next we will set a purely hydrodynamic accretion disk in 2D, and learn to use more advanced visualization tools like Paraview and VisIt. I will also show the use of Python for visualization.
On the example of adding the magnetic field in the accretion disk simulation, we will next learn the basics of the magneto-hydrodynamic simulations, both in ideal and non-ideal (viscous and resistive) approaches.
I will show how to use a Linux cluster queuing systems for simulations, and how to plot the magnetic field lines. In the last lecture, we will learn setting of the full 3D magnetic accretion disk and visualization of the results.**

Lectures “Introduction to PLUTO code”



-Last year in Shanghai, this year in Warsaw, Zhongli and Opava

-I will continue providing such lectures where people would find it useful.

-It is good also for starting collaborations in different kinds of problems.

Work with CAMK PhD students

- With Ruchi Mishra we work on midplane backflow in accretion disk.

- With Fatima Kayanikhoo, we compare PLUTO and Koral results in Orszag-Tang problem in 2D and in 3D.

Summer students 2021

- We took **five** summer students in 2021, **two** worked with Fatima on strange stars: Marcin Kapusta (UW) and Patryk Liniewicz (UJ Krakow).

- I worked with **three** students from Warsaw University on PLUTO simulations:

  -Barbara Białek: setup of thin disk around a black hole with PLUTO

  -Maja Gwizdalska: setup of SANE simulations with PLUTO

  -Filip Cieciuch: Magnetospheric interaction with non-dipole stellar fields

  -a poster at 40th Polish Astronomical Society meeting, **PTA proceedings**

Non-dipolar stellar fields

Filip Cieciuch, Miljenko Čemeljić

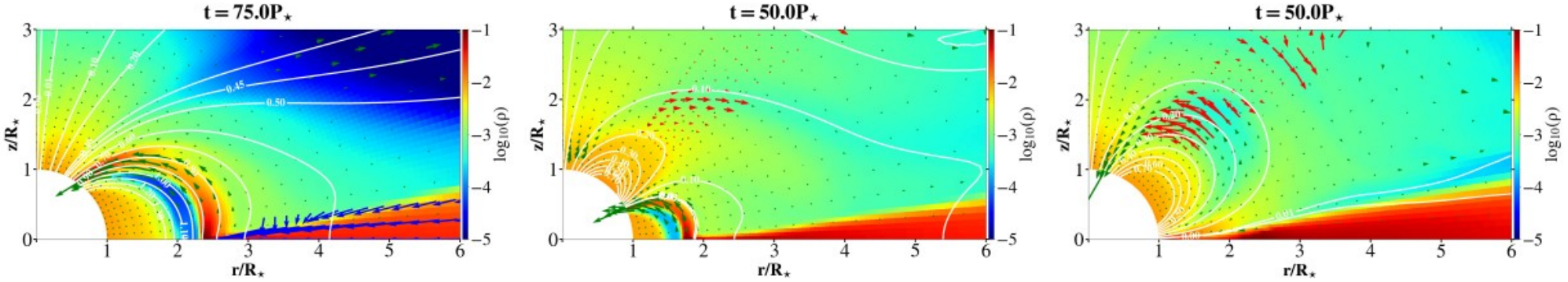


Fig. 1: Zoom into the vicinity of the star in quasi-stationary results in our simulations in the dipole, octupole and quadrupole field cases, left to right, respectively, with time measured in stellar rotation periods. The density is shown in the logarithmic color grading, poloidal magnetic field lines are shown with white solid lines, and vectors of poloidal velocity (normalized to the Keplerian velocity at the stelar equatorial surface) are multiplied with the factors 15 (in the disk) and 3 (in the corona).

Non-dipolar stellar fields

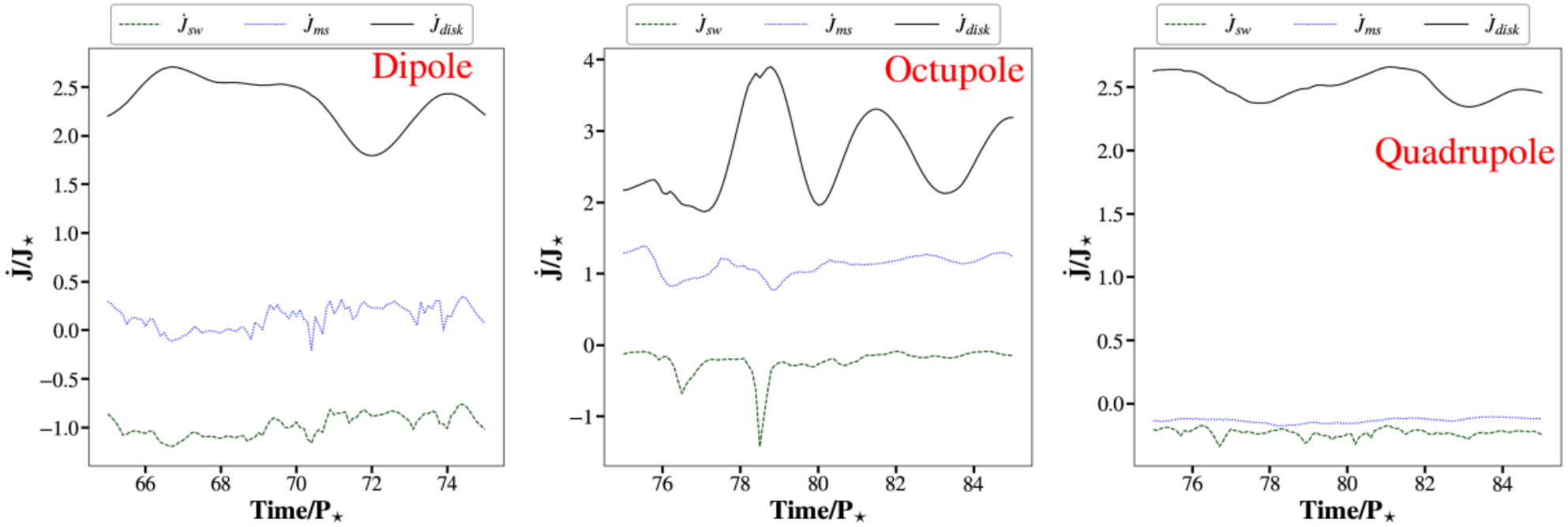


Fig. 3: Angular momentum flux during the quasi-stationary interval in our simulations computed in the "stellar wind" above the disk, $\dot{J}_{sw}$ (dashed green line) and accross the disk $\dot{J}_{disk}$ (solid black line) are computed at the half of the computational box $R = 15R_\star$. The "magnetospheric" angular momentum flux $\dot{J}_{ms}$ (dotted blue line) we compute above the disk, at the distance $R = 1.5R_\star$, at which in all the three geometries the initial field is the same.

Meetings, grants

- Workshop organized by an international collaboration: "*Feeding the spinning top -Spin evolution of accretion-powered pulsars in HMXBs.",* on a grant from International Space Science Institute (ISSI) – a very good venue, ISSI provides grants for organizing meetings, workshops.

- One week workshop in Silesian University in Opava, Czech Republic, by our PhD candidate David Abarca, to learn using the Koral code. This brings me to work with (radiative) GRMHD.

- With members of our group, in December 2021 I applied for OPUS 22 grant by NCN on the topic of "*Accretion simulations for the Event Horizon Telescope: inferring the space-time metric from black hole shadows*".

Publications, reviews

- **Published**: 2021 MNRAS, 500, 506, Vinković, D.; Čemeljić, M.: "*Inner dusty regions of protoplanetary discs - II. Dust dynamics driven by radiation pressure and disc winds*"
- **Submitted**:

  -revision to be sent to A&A: Čemeljić, M., Kluźniak, W., Parthasarathy, V.:"*Magnetically threaded accretion discs around millisecond X-ray pulsars in resistive MHD simulations and asymptotic expansion*"

  -sent to ApJ: Čemeljić, M., Yuan, F., Yang, H., Shang. H., "*Flares and associated episodic jets from black hole and protostellar accretion*"

  -sent to PTA Proceedings: Cieciuch, F., Čemeljić, M., "*Star-disk magnetospheric interaction with non-dipolar stellar field*"
- **Reviewed**:

  - a paper for Astronomy & Astrophysics

  - a grant review for French ANR

Thank you!