The Milky Way in a phase and coordinate spaces

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19 апреля 2018

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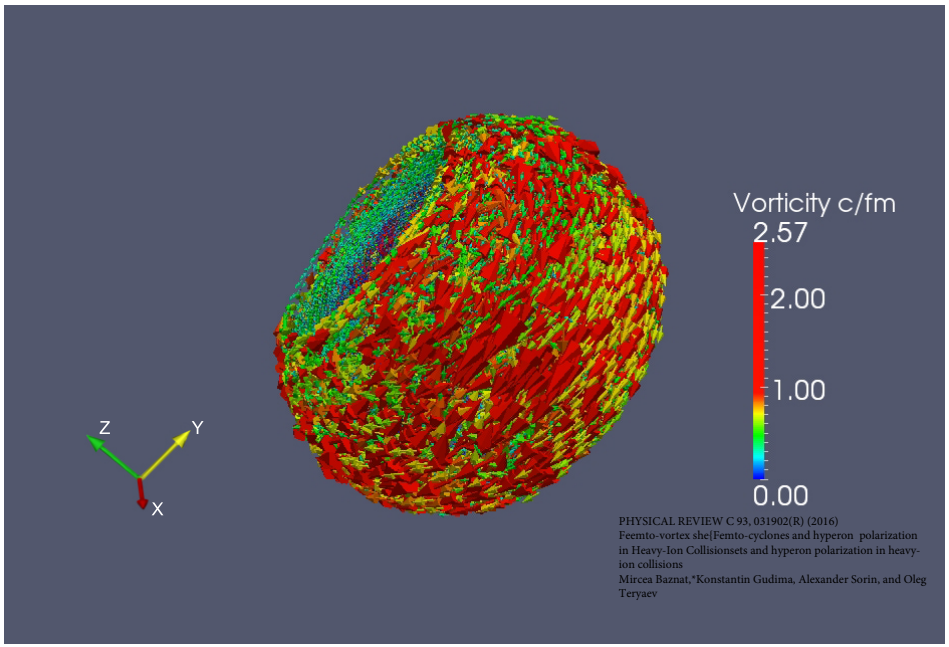
Spiral structures in Heavy Ion Phisics

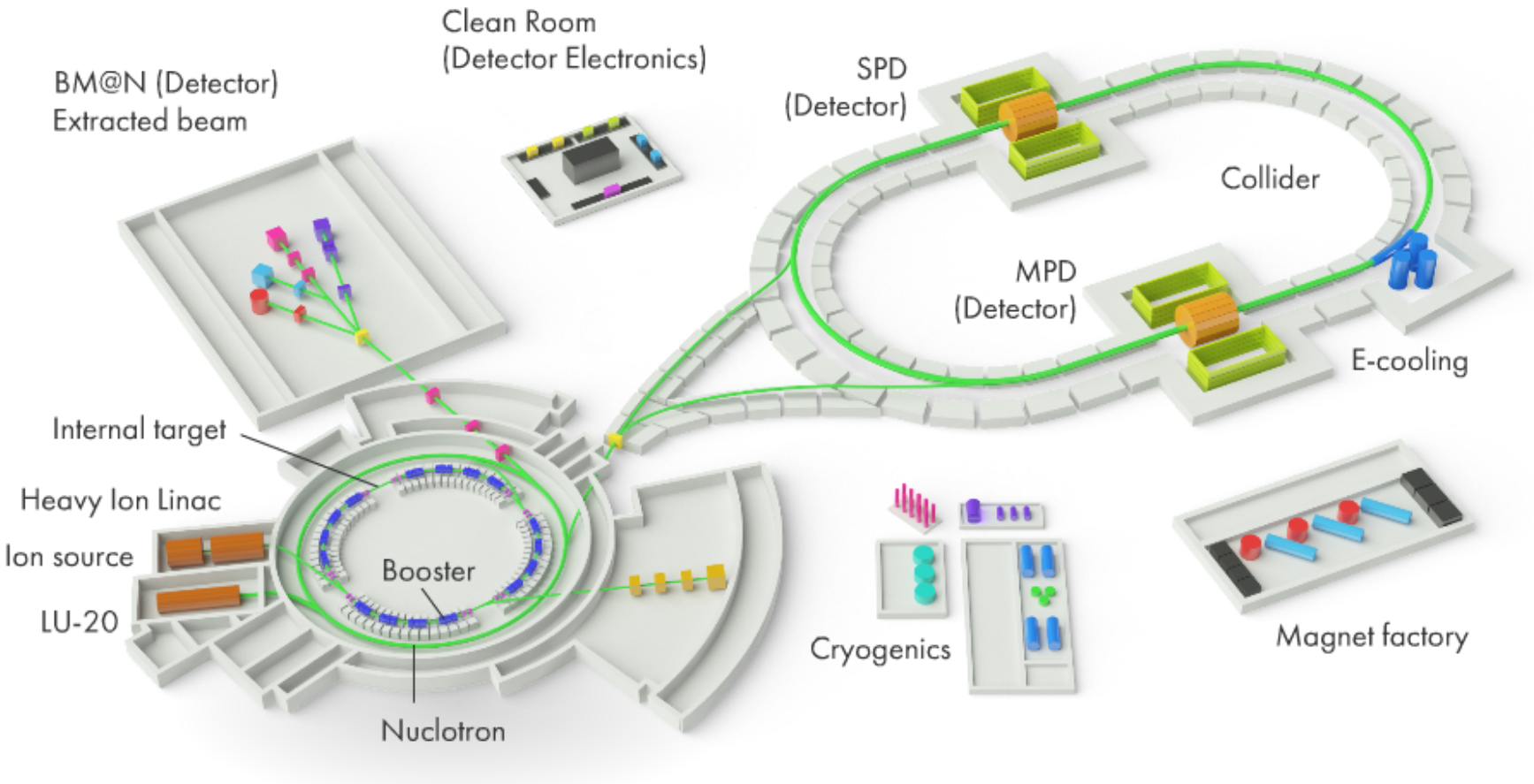
Motivations:

- The possibility of observing collisions in heavy-ion physics only in phase space
- Comparison of structures arising in heavy-ion physics and in spiral galaxies

The appearance of vortex layers ("small galaxies") in the heavy ions collision



Spiral structures in Heavy Ion Phisics

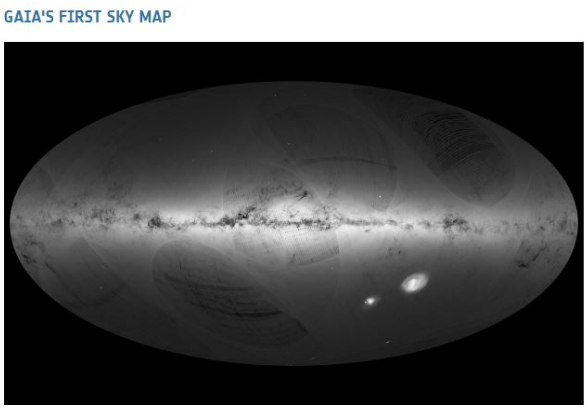


Spiral structures in Heavy Ion Phisics

Motivations:
In paper

Statistical analysis of 2D patterns and its application to astrometry
Petr Zavada and Karel Piska
arXiv:1602.01812v2 [hep-ph] 14 Feb 2016

is discussed application of the method, based on the use of the Fourier expansion of azimuthal distributions of produced particles in in Heavy Ion Phisics for astrometric data, obtained by GAIA mission



Gaia is a mission to chart a three-dimensional map the Milky Way and the Local Group, in the process revealing the composition, formation and evolution of the Galaxy.
(http://sci.esa.int/gaia/)

The construction of the galaxy rotation curve in order to study the spiral structures in the phase space

The velocity v of matter in the galaxy:

$$v(r) = \sqrt{\Sigma_i^n (v_i)^2} \qquad (1)$$

$$v(r) = \sqrt{\frac{MG}{r}}, \qquad (2)$$

$$M = \int_a^b \rho(r) d^3 r, \qquad (3)$$

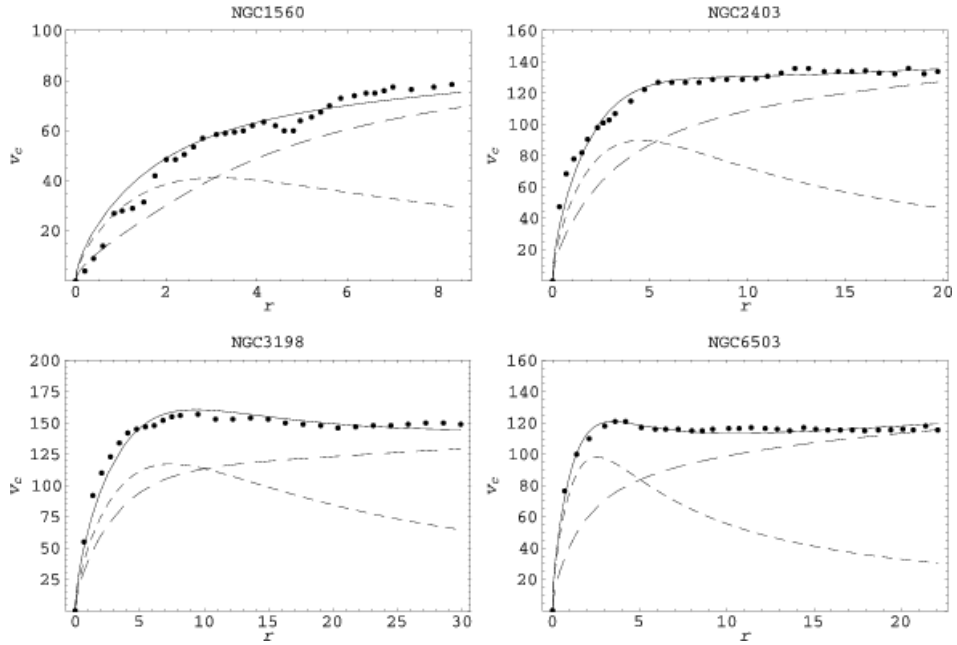


Рис.: Example of NGC1560, NGC2403, NGS3198, NGC6503 rotation curves

The construction of the galaxy rotation curve in order to study the spiral structures in the phase space

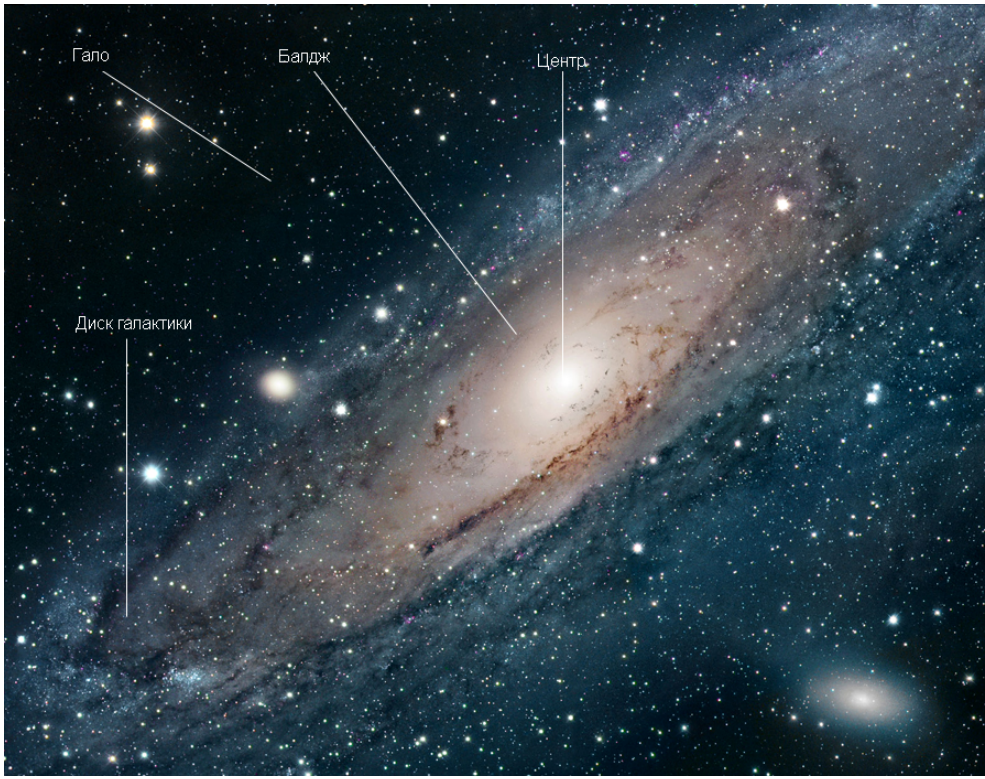
Components influenced on rotation curve:

- Bulge
  Lower mass estimate -
  $0.8 - 1 \times 10^{10} M_{solar}$
- Thin stellar disk:

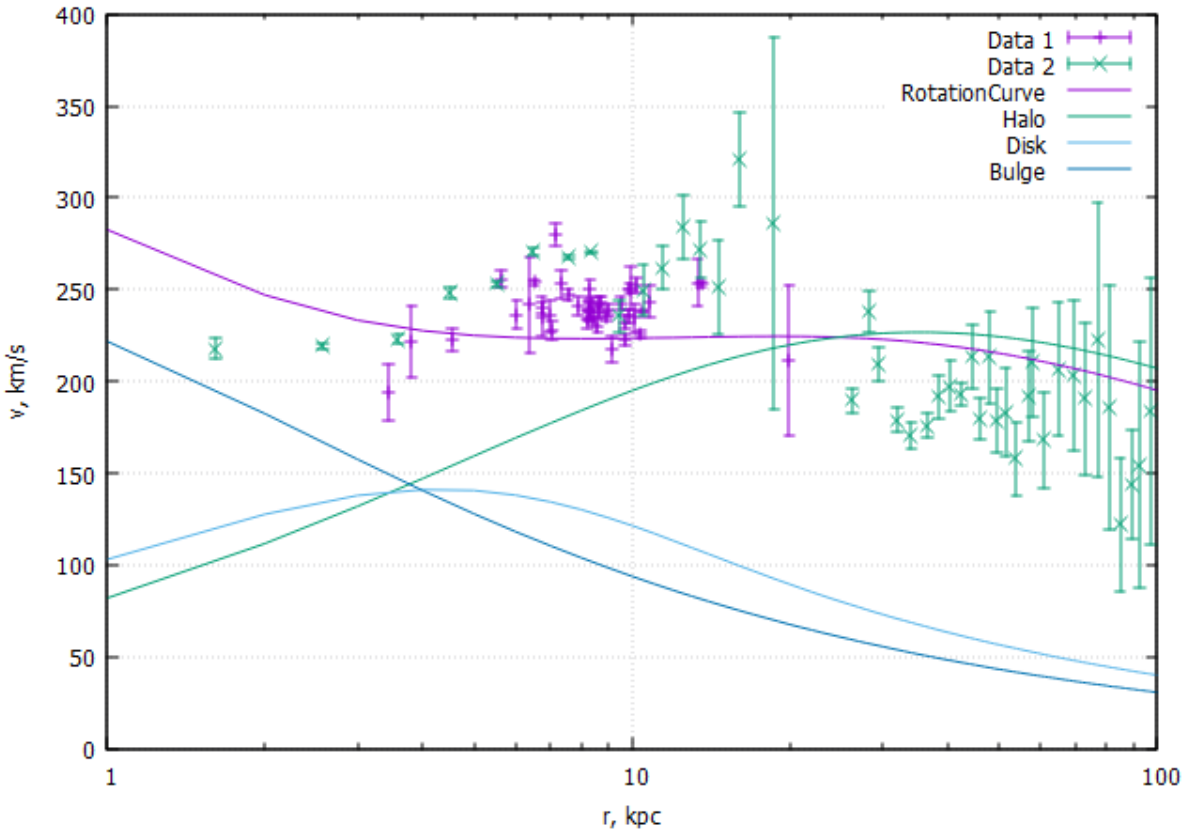
$$\sigma_D = \frac{M_D}{2\pi R_D^2} exp \frac{-r}{R_D} \qquad (4)$$

- Navarro-Frenk-White(NFW)
  Dark halo

$$\rho(r)_{NFW} = \frac{\rho_s}{\frac{r}{r_s}(1+\frac{r}{r_s})^2} \qquad (5)$$



The construction of the Milky Way rotation curve



Data 1 from "A revised rotation curve of the Milky Way with maser astrometry"
Xiao-Sheng Xin and Xing-Wu Zheng
Data 2 from "Rotation curve of the Milky Way out to ~200 kpc"
Pijushpani Bhattacharjee, Soumini Chaudhury, and Susmita Kundu

The rotation curve based on bachelor's work
(With Gladyshev A.V. as scientific superviser)

Construction of the hodograph of the Galaxy in the coordinate and phase spaces

Components of godograph in the coordinate space:

$$\xi[r] = rsin(\frac{V(r)T}{r} + \phi)$$
$$\eta[r] = rcos(\frac{V(r)T}{r} + \phi) \quad (6)$$

With the known inverse function $R(v)$, the angular rotation velocity of the velocity vector is determined by the value $\frac{v}{R(v)}$. Godograph components in the phase space:

$$\xi[v] = vcos(\frac{vT}{R(v)} + \phi),$$
$$\eta[v] = vsin(\frac{vT}{R(v)} + \phi) \quad (7)$$

with ϕ as an initial phase

All stars rotate clockwise

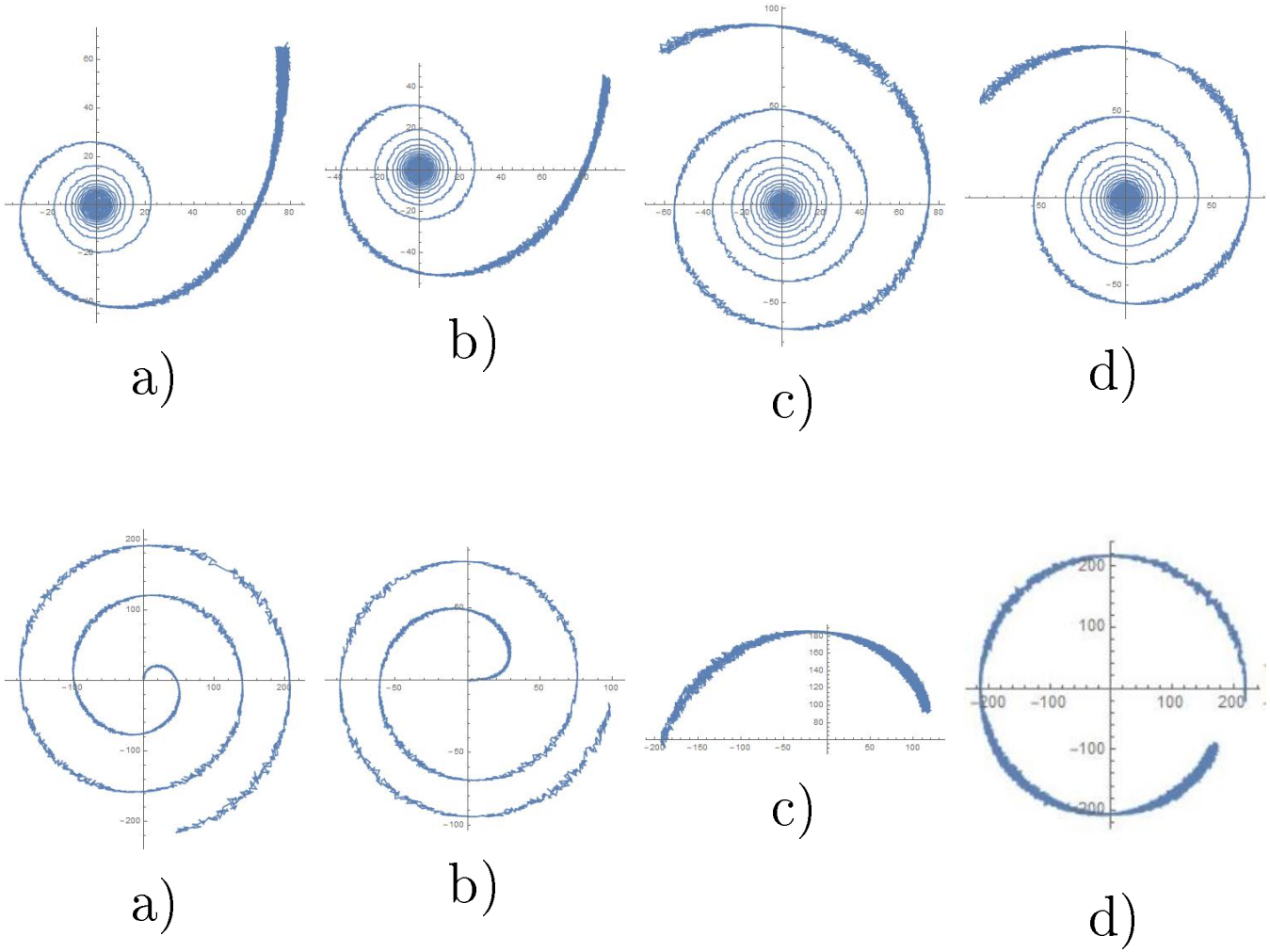


Рис.: Godographs of components and the rotation curve of the Milky way in the coordinate (up) and **phase**(down) spaces: a) Bulge, b) Stellar disk, c)Dark matter, d)Rotation curve. The spirals are twisted in different directions

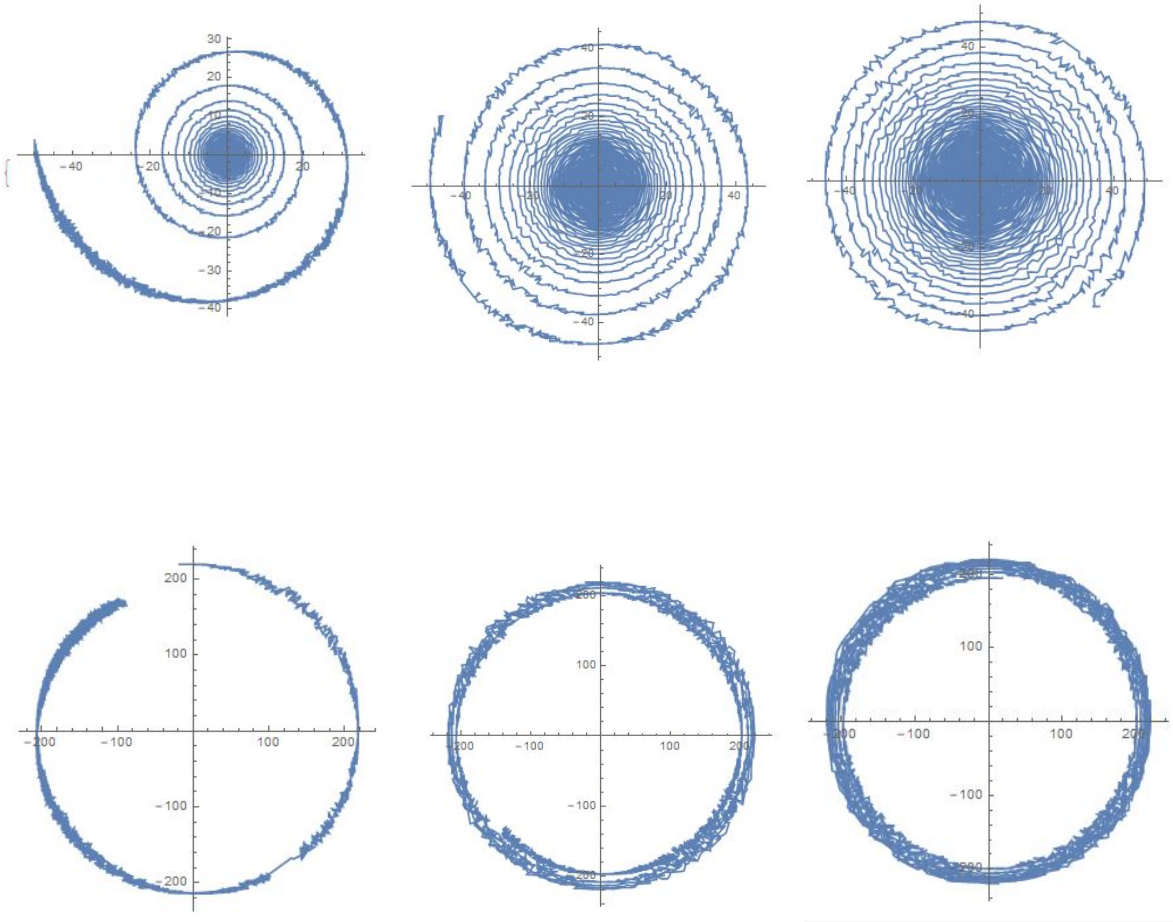


Рис.: Time depending of helical structures in the coordinate (up) and **phase** (down) spaces

Conclusion

- The helical structures in coordinate and velocity space are found and compared
- Individual components in the phase space are twisted in different directions

We are going to

- study spiral structure using GAIA data in common with Institute of Physics AV CR (Prague)
- Development of algorithms for searching for spiral structures in data on heavy ion collisions

Thanks for your attention!