Thick tori and flows around rotating boson stars

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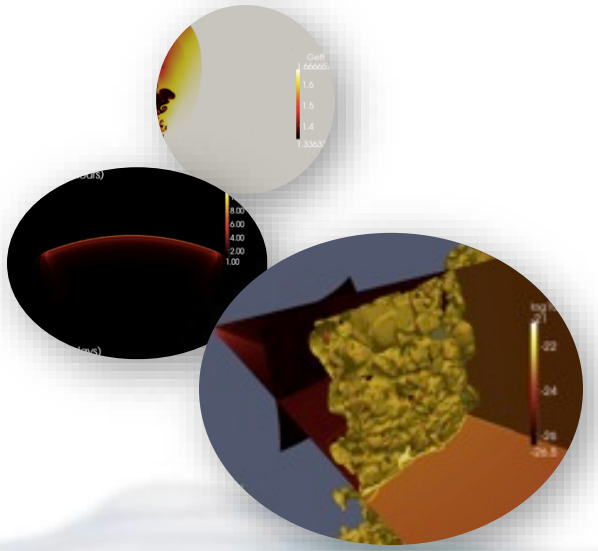
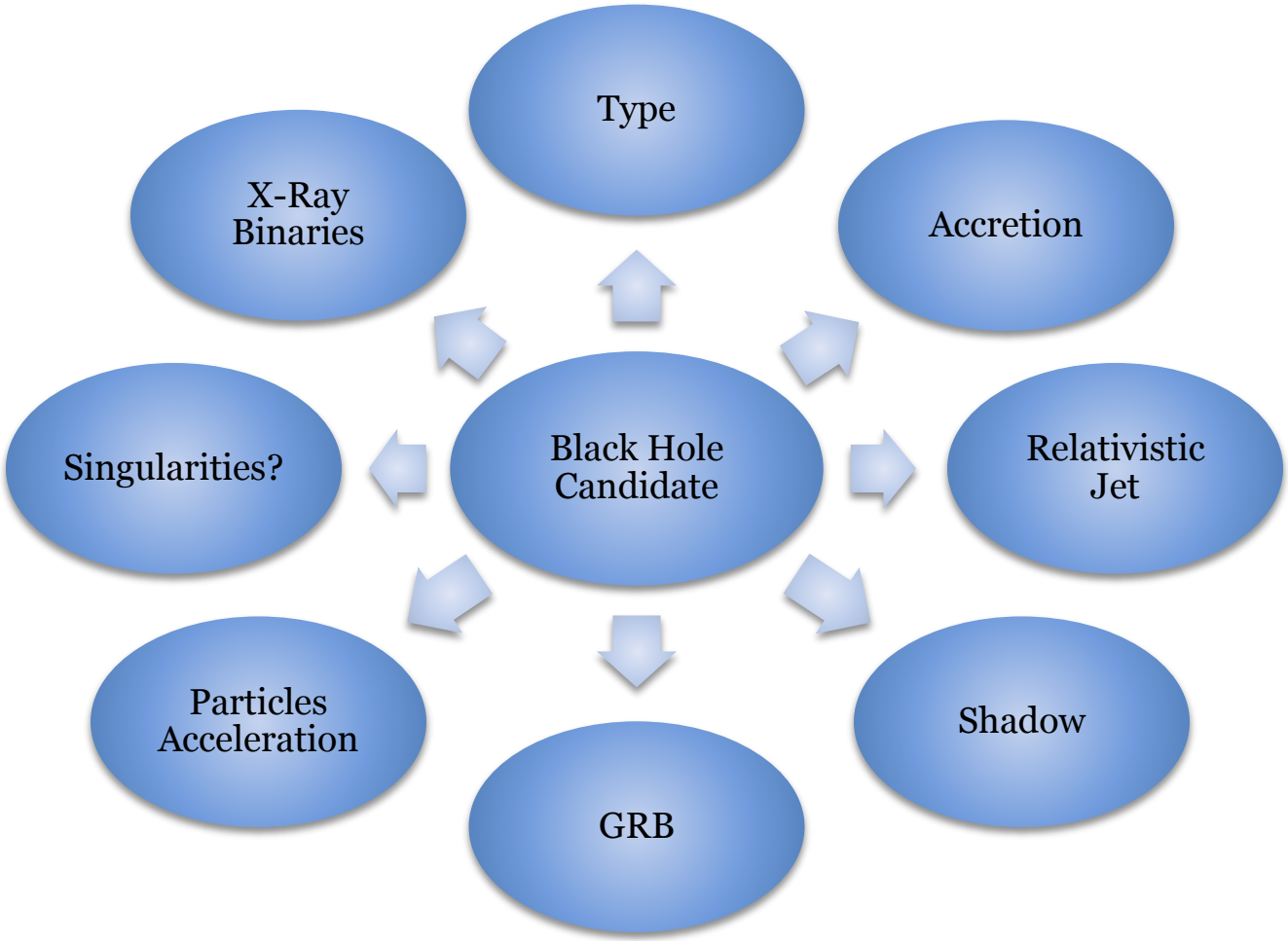


P. Grandclement | F. Vincent | E. Gourgoulhon | F. Casse | O. Straub | F. Dauvergne

Outline of the talk

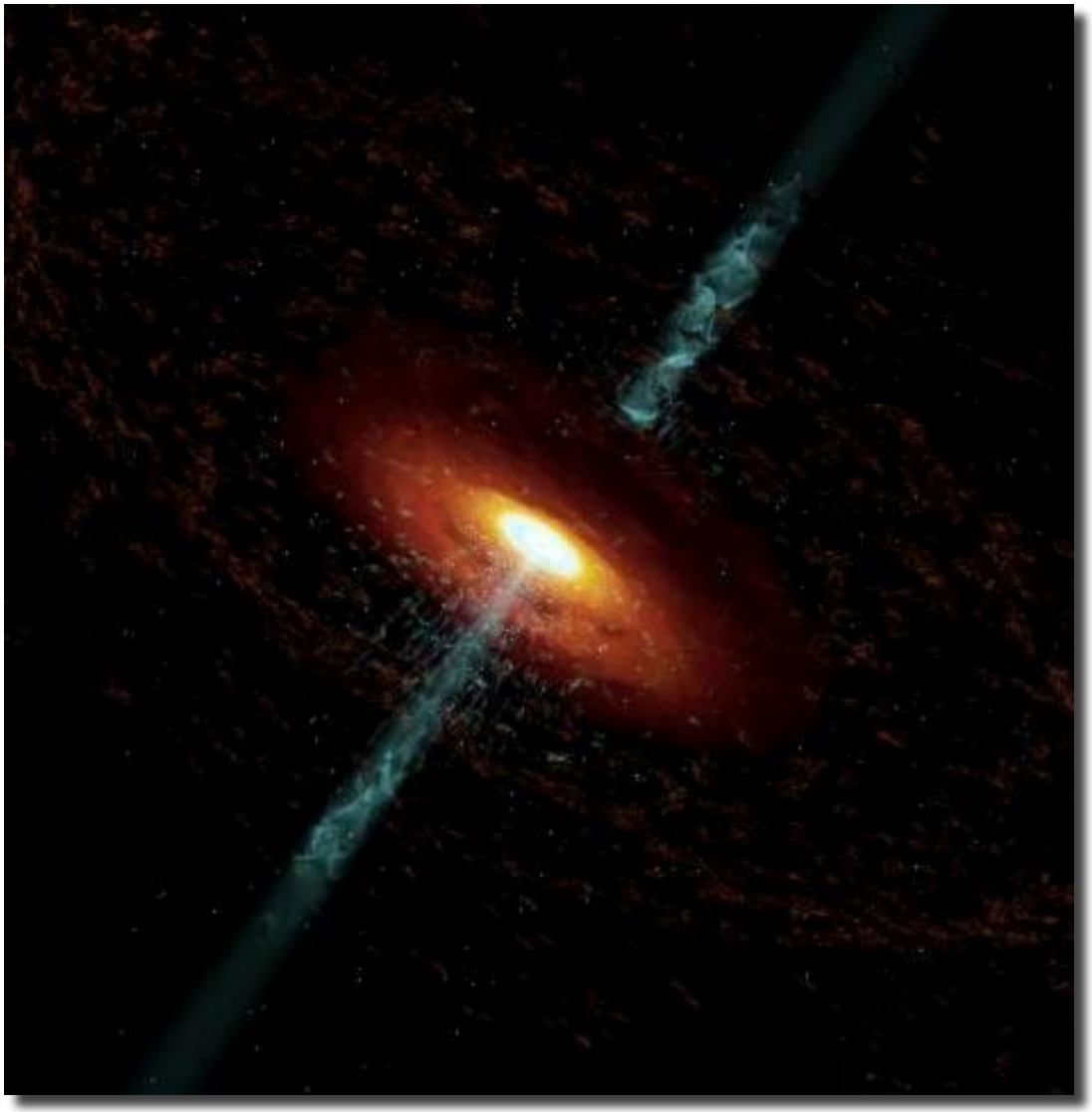
- Motivations
- Torus proprieties
- Spherical accretion onto Boson star
- Accretion-ejection
- Conclusion

We need to study Black Hole Candidate

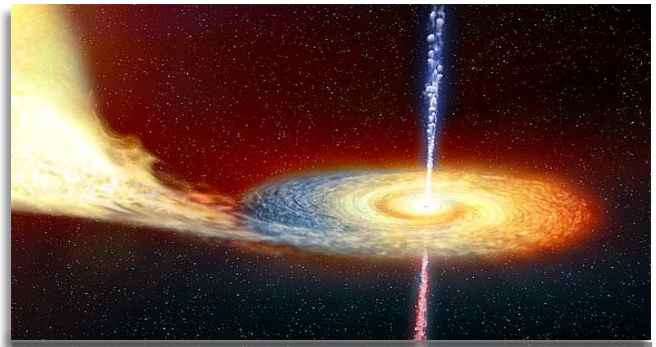


Why study flow in the vicinity of Boson star

- Boson exist
- Mass of Boson star could reaches Massive BHC?
- Boson star can be BHC.
- New generation of instruments.
- Predict observational differences between BS and BH as central object candidate.

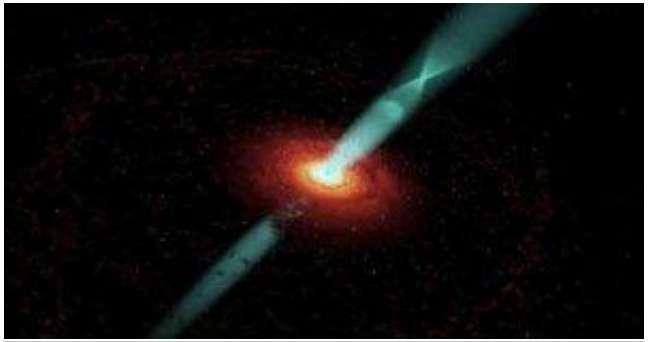


Accretion-ejection close to compact objects



Microquasar

Active Galactic Nuclei



Relativistic jet

Differences Boson star/ Black Hole

Rotation

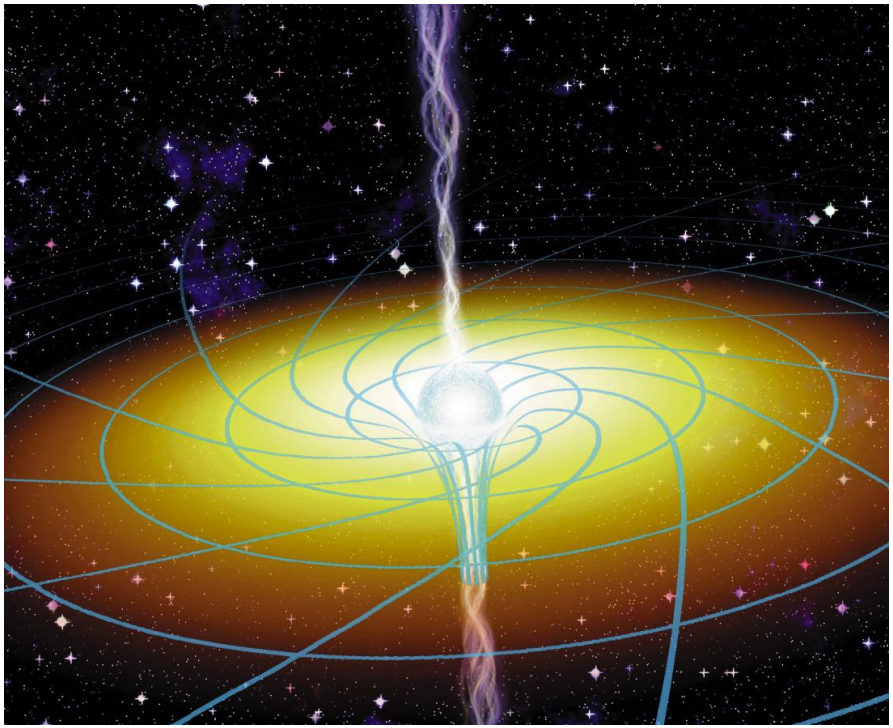
- Matter undergoes different Less-Thirring

Horizon

- Matter propagates inside/ouside BS

Shape

- Different geodesic

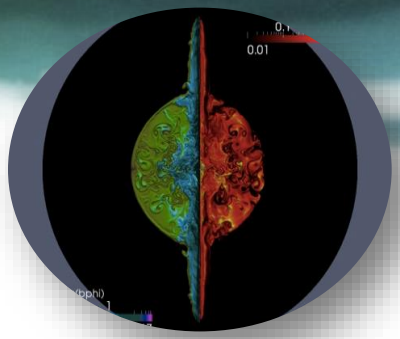


Boson stars

k	ω [m/ħ]	M [m_p^2/m]	a/M	r_{ico}/M	ergosphere
0	0. 771	0. 53549	0	0	No
0	0. 8117	0.6119	0	0	No
1	0.8	1.30779	0.8021	1.208	No
2	0.8	2.01642	1.0509	1.95	No
4	0.8	2.51739	1.2723	6.047	Yes

k : rotational quantum number
ω : field pulsation
M : Boson star mass
a : reduced angular momentum a=J/M
r_{ico}: Innermost cirucal orbit

Grandclement et al. 2014



Torus in the vicinity of BH/BS

Analytical Model

Meliani et al. 2015.

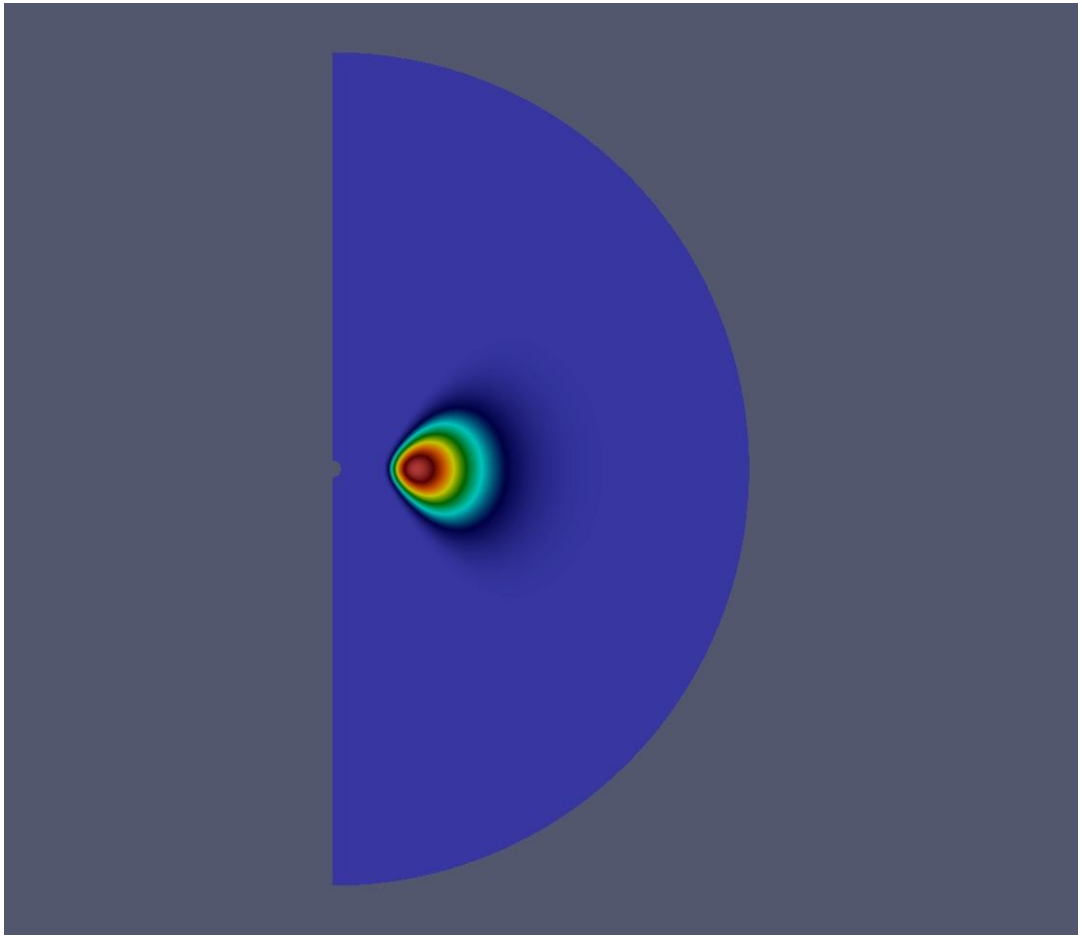
Torus model

Model of Tick Torus

- Propose : Abramowicz et al 1978

Characteristics:

- Constant specific angular momentum
- Inner radius
- Cusp : accretion
- At center : Keplerian rotation



Stationary torus close to Kerr black hole

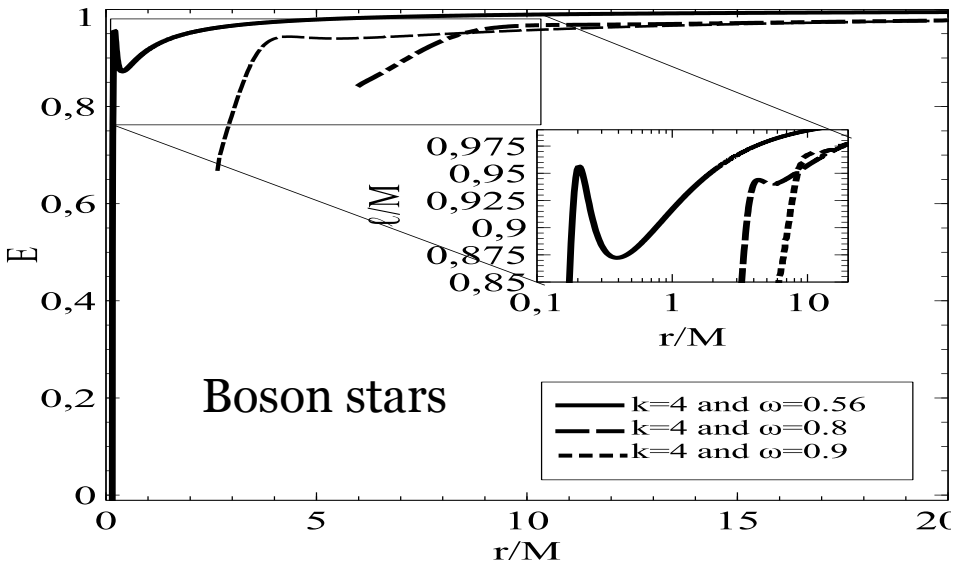
Circular Orbit

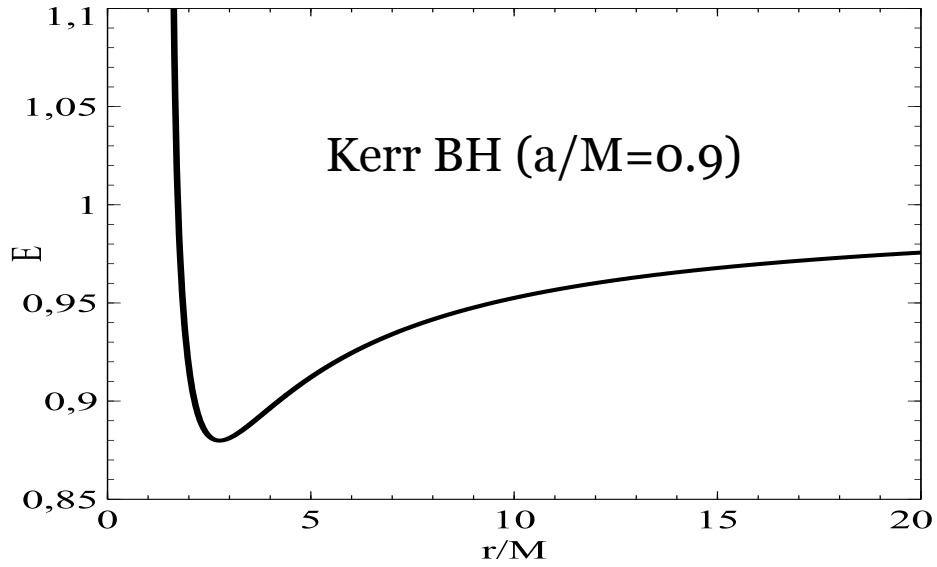
Similarity

- There is last stable orbit for BH and rotation BS.

Difference

- BS:
  - Last stable orbit inside the star
  - All stable orbits are bounded
- BH
  - Last stable orbit outside horizon
  - innermost stable circular orbit.





Thick torus model

l_{max}

- The maximum allowed angular momentum.

l_k

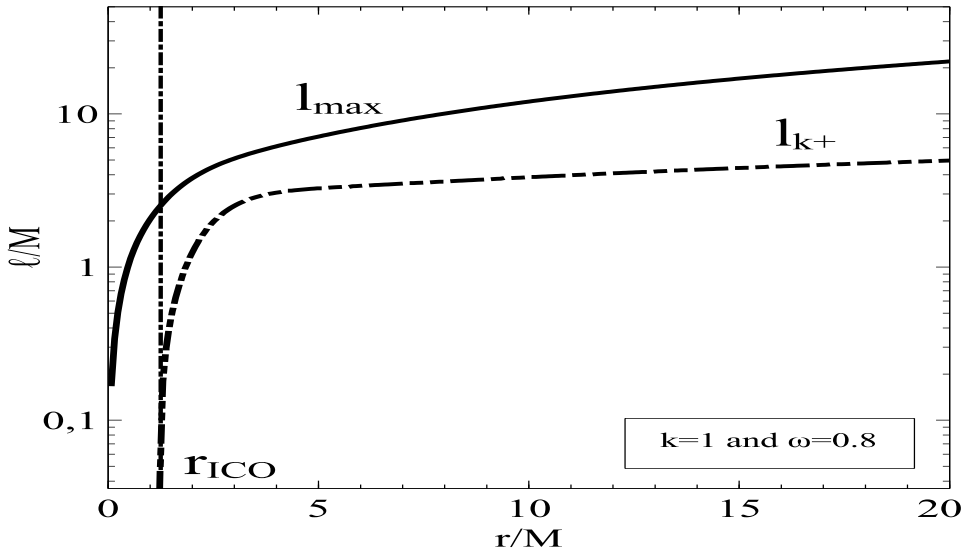
- Keplerian angular momentum.

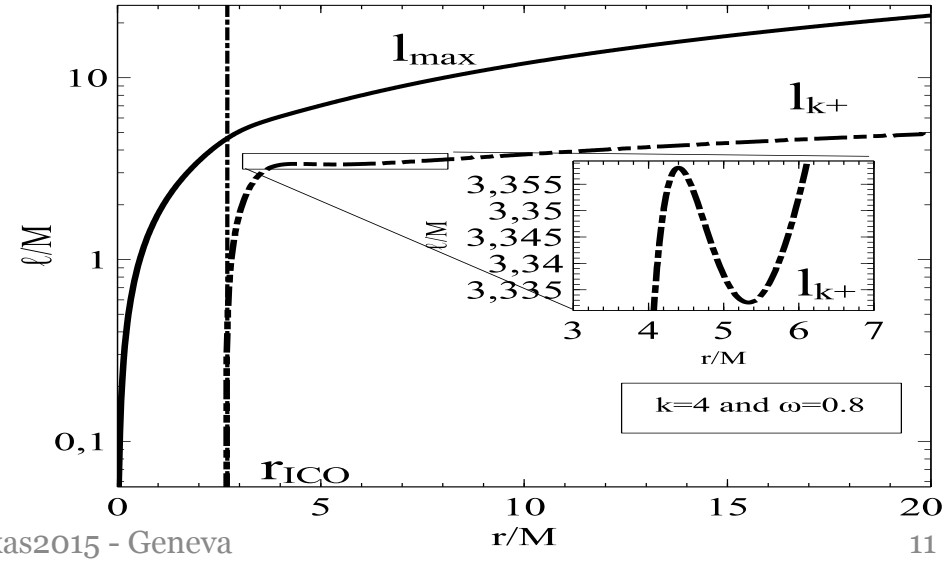
Relativistic BS

- Keplerian angular momentum oscillate near the BS center.

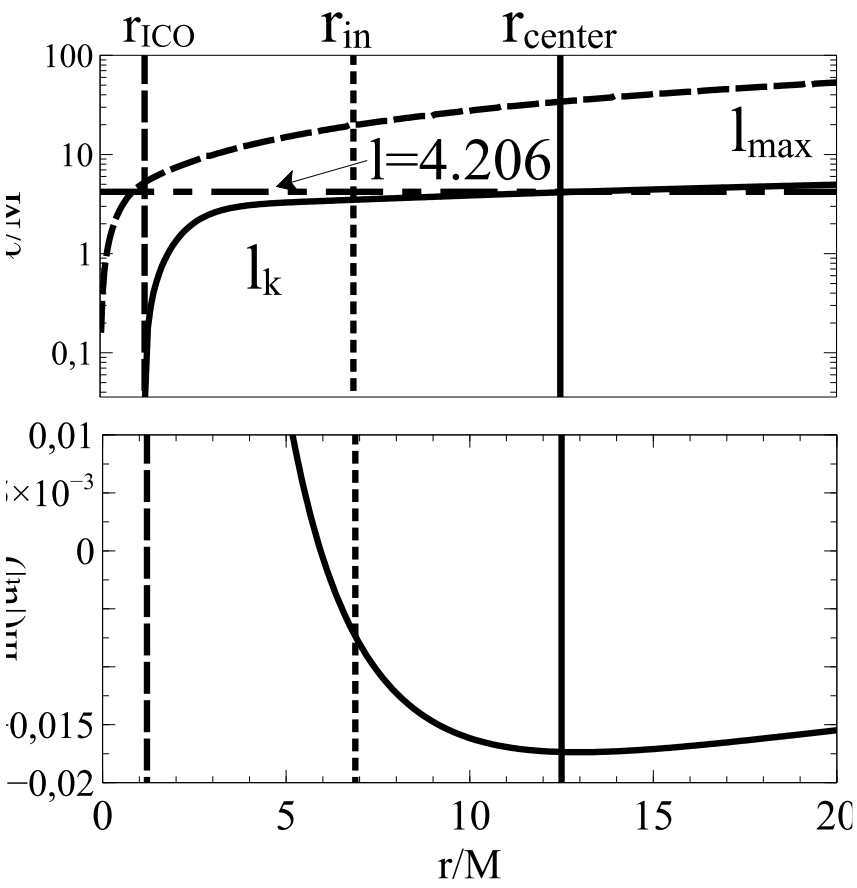
Less relativistic BS

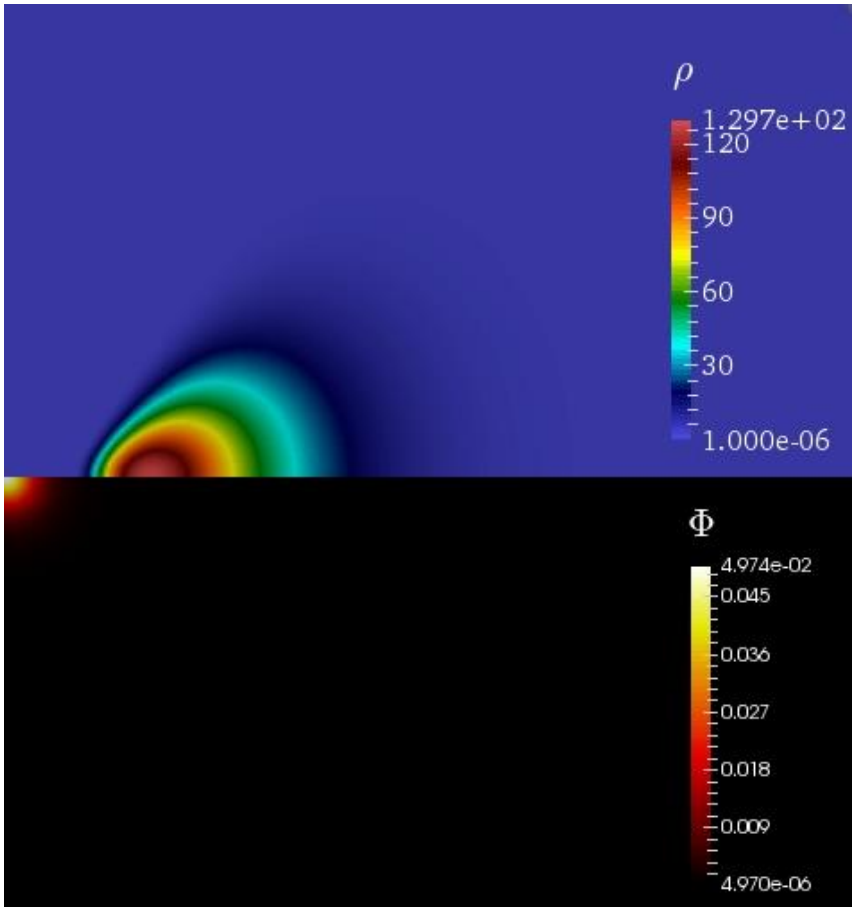
- Has no-cusp



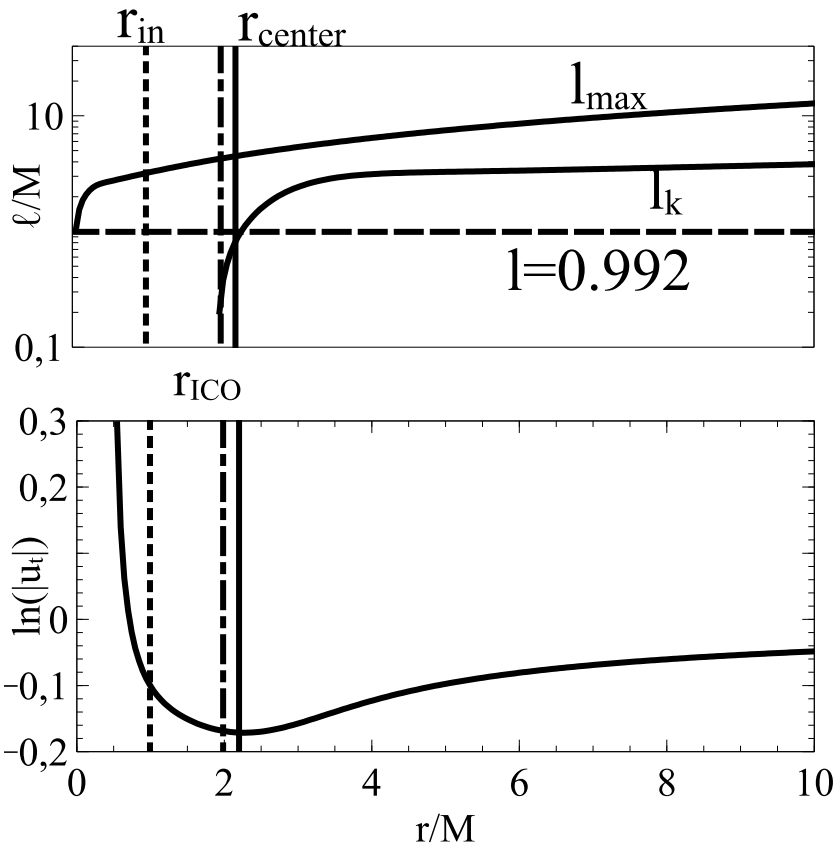


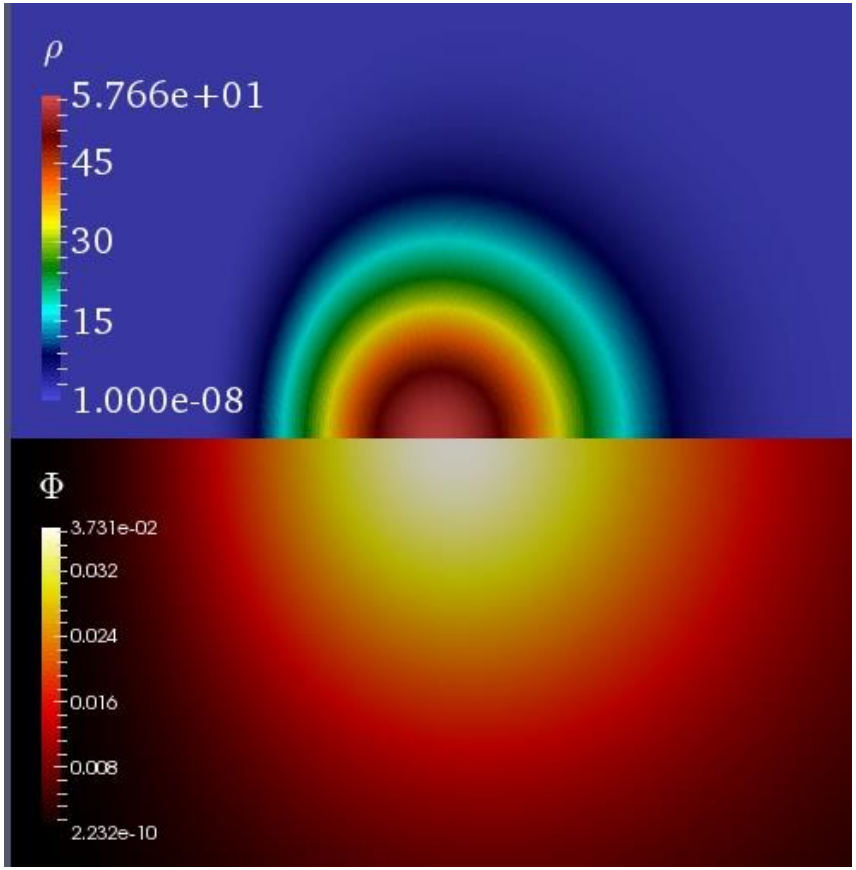
Thick Torus ouside BS torus and without cusp



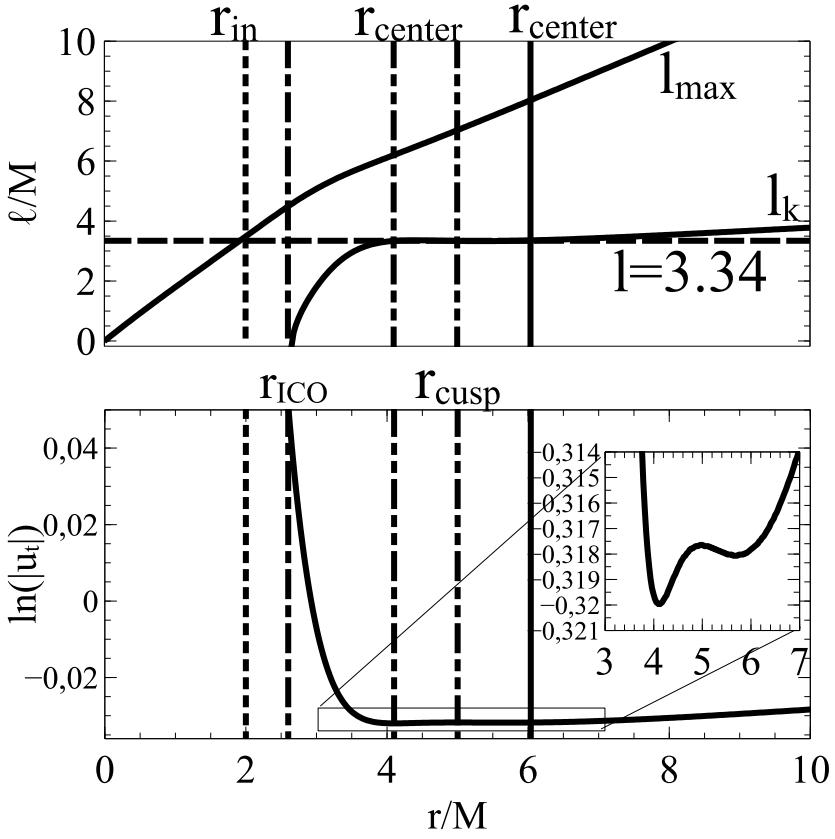


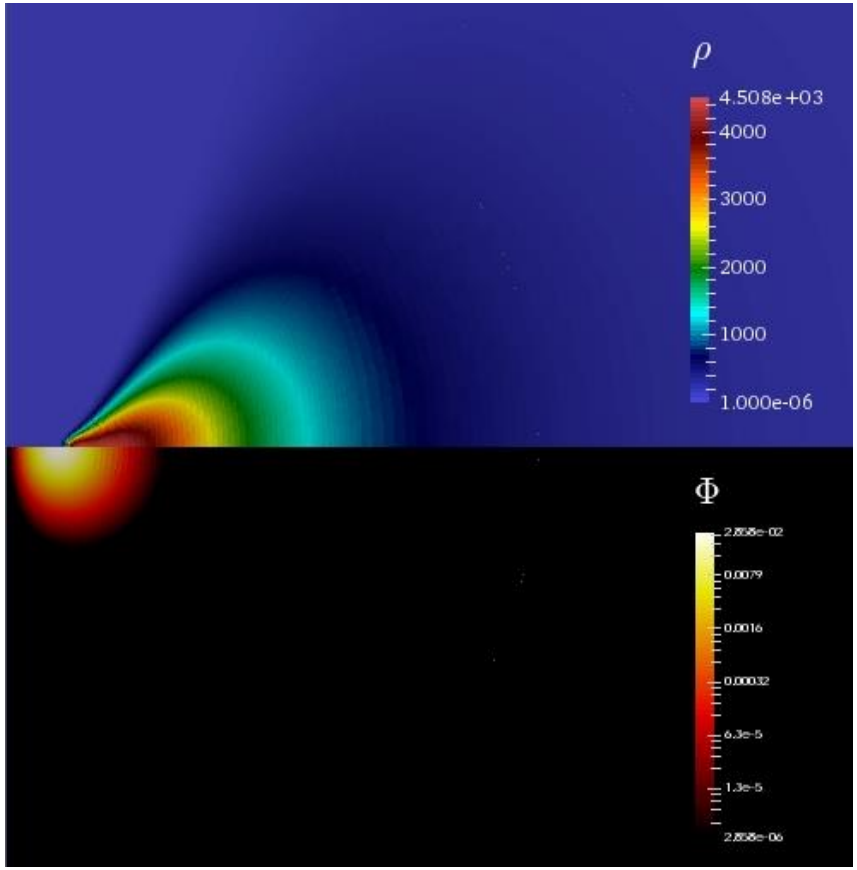
Matter thick torus coincide with BS and without cusp





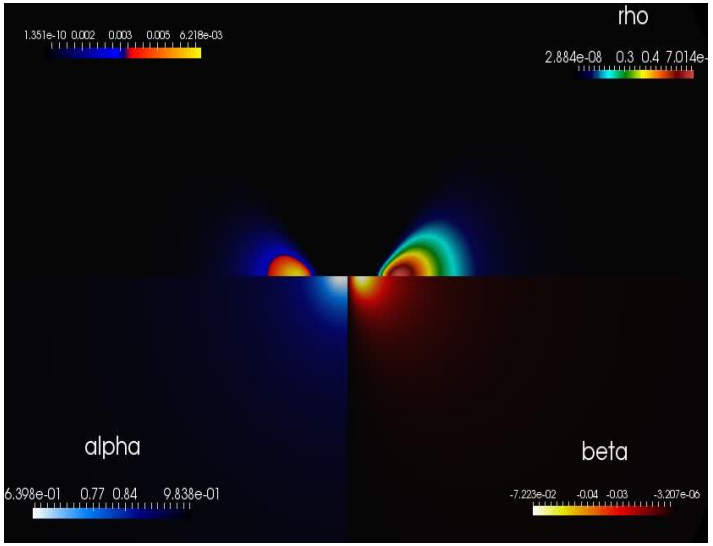
Thick Torus inside BS torus and with cusp

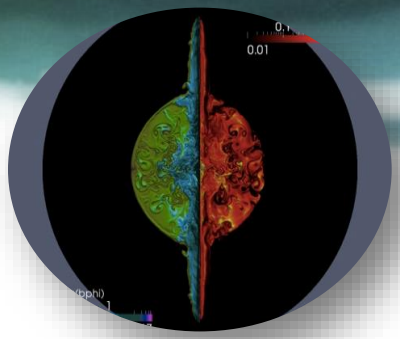




Differences BH/BS

Cusp	• BS: Not all BS could have torus with cusp • BS: Torus could have 2 centers and 2 cusps
Inside Compact Object	• BS : YES • BH NO
Last stable orbit	• BS: inside • BH: outside
Marginally bound	• BS: No • BH: Yes



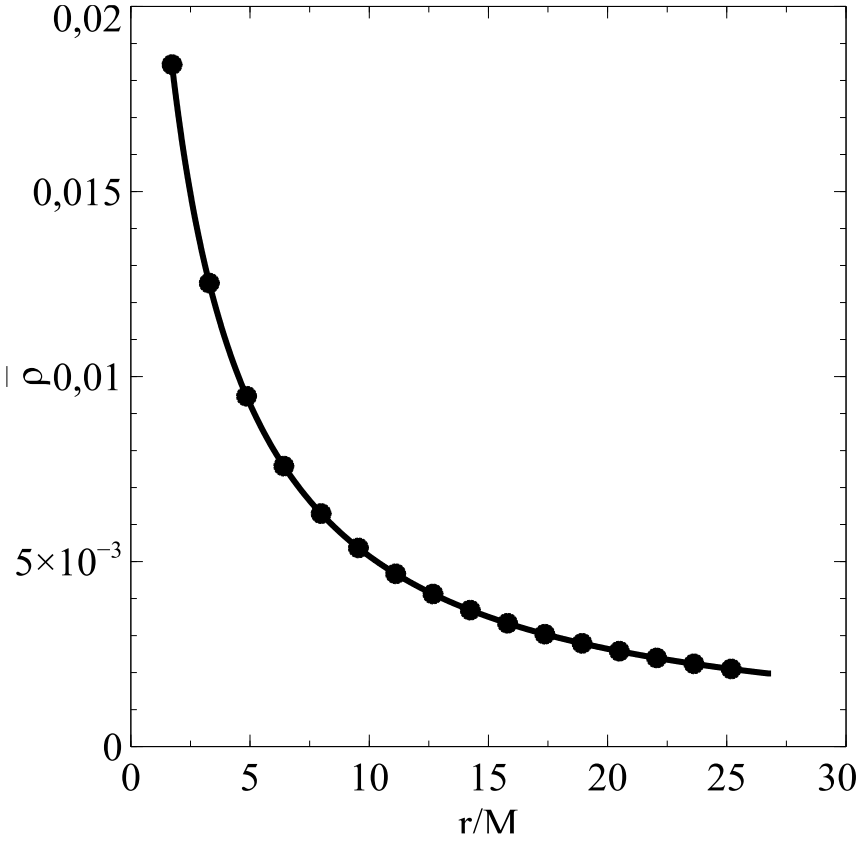


Spherical accretion

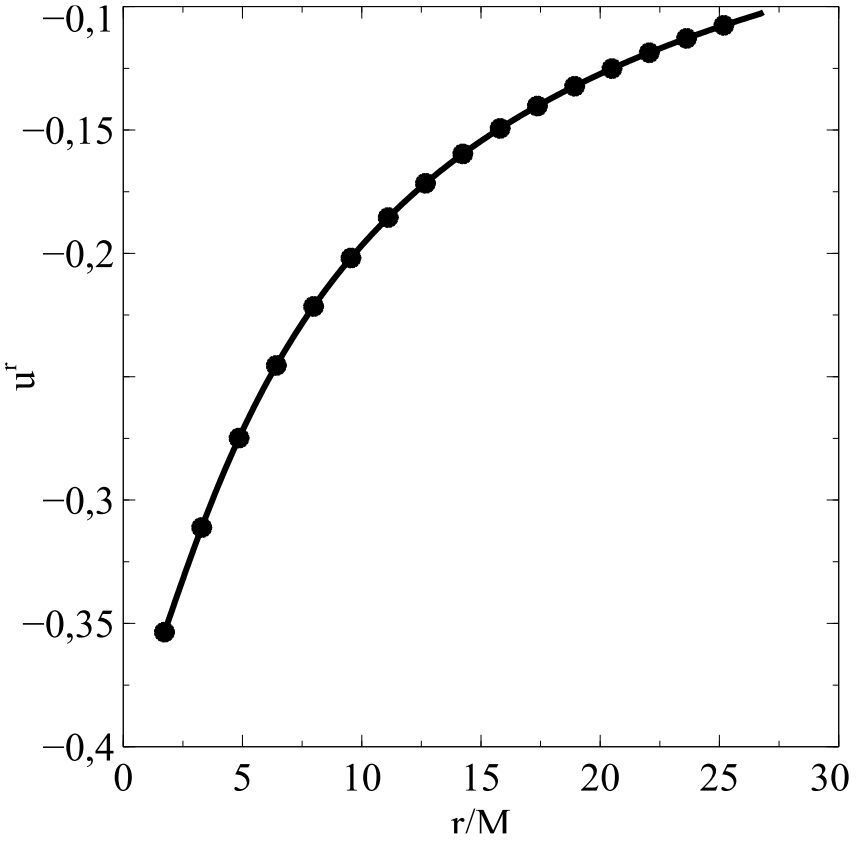
Boson stars with k=0

Test Spherical Accretion : k=0 and ω=0.771 m/ħ

Density profile

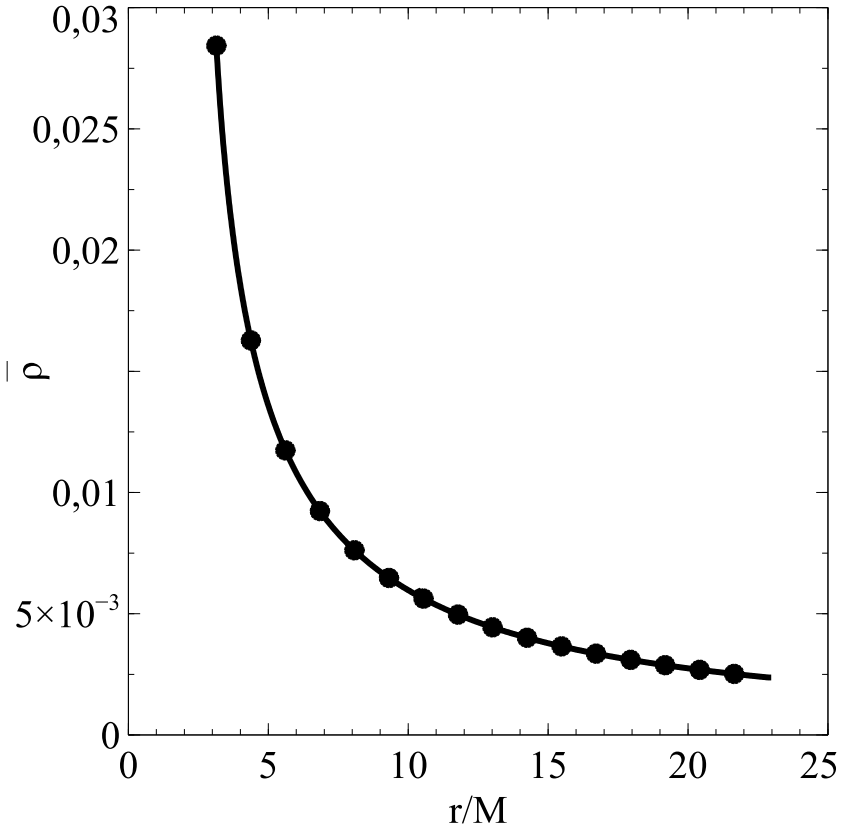


Velocity profile

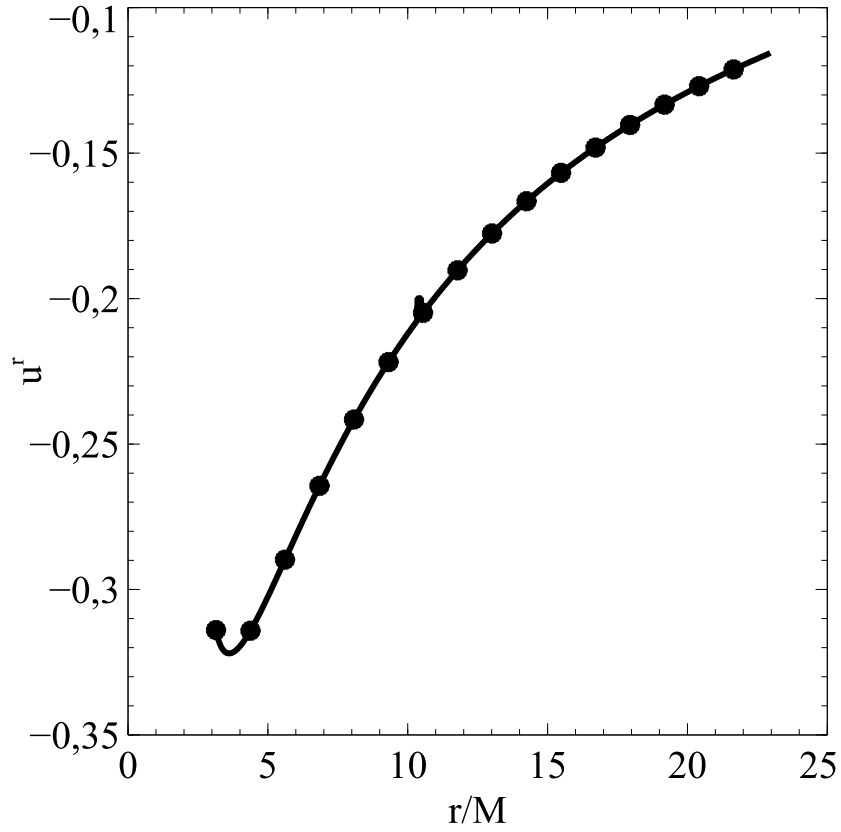


Test Spherical Accretion : k=0 and ω=0.71m/ħ

Density profile

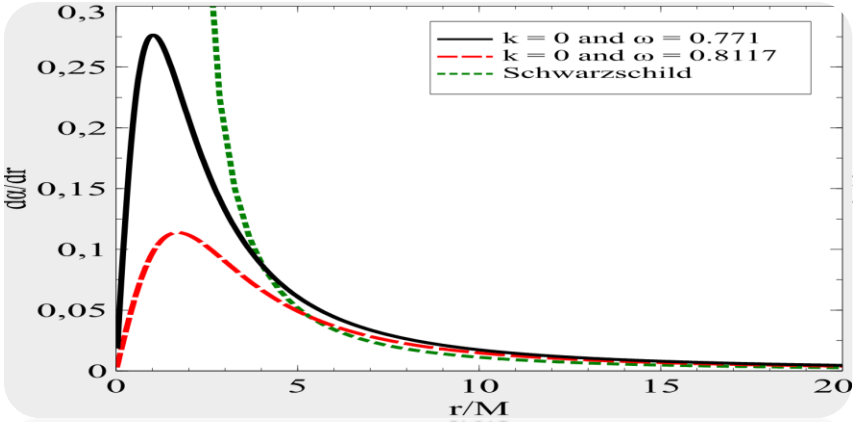


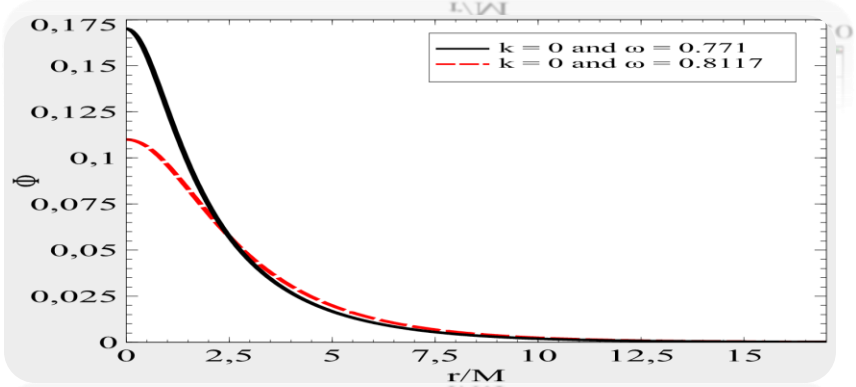
Velocity profile



Spherical wind BS/BH

Lapse function

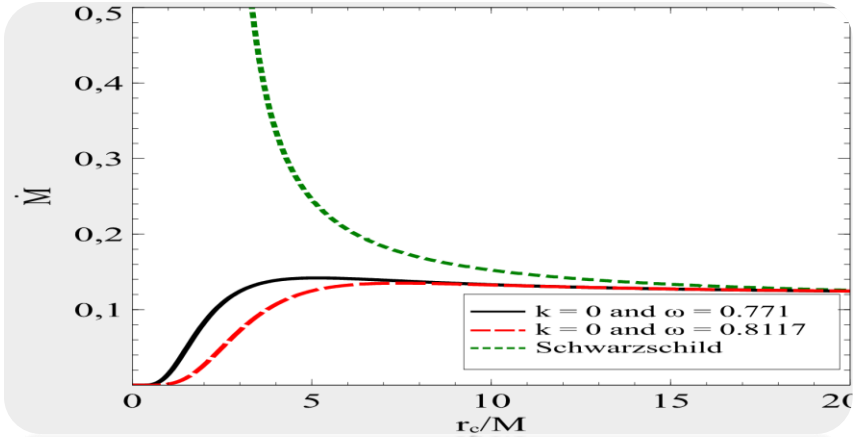




Scalar field

Accretion rate in function of sonic surface position

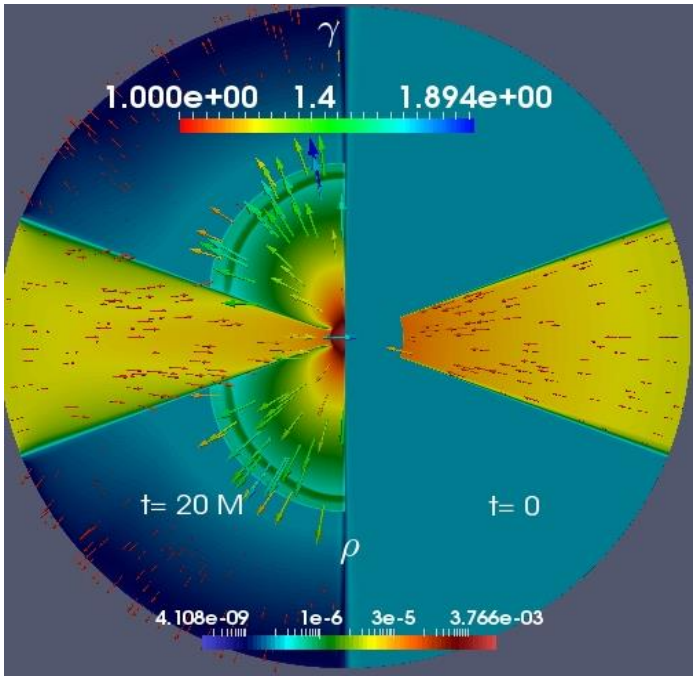
Mass flux

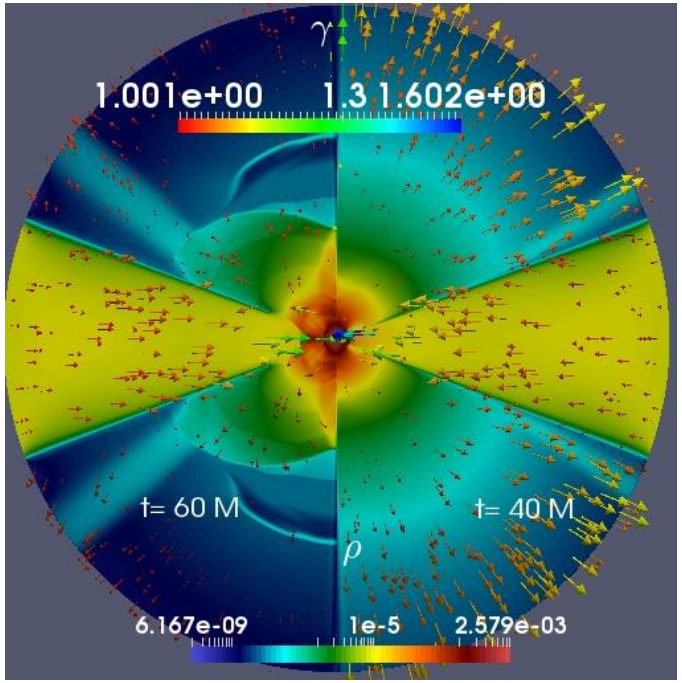


BS: accretion is manly constant

Accretion-wind structure (Boson star)

Thin accreting disc on spherical Boson star.

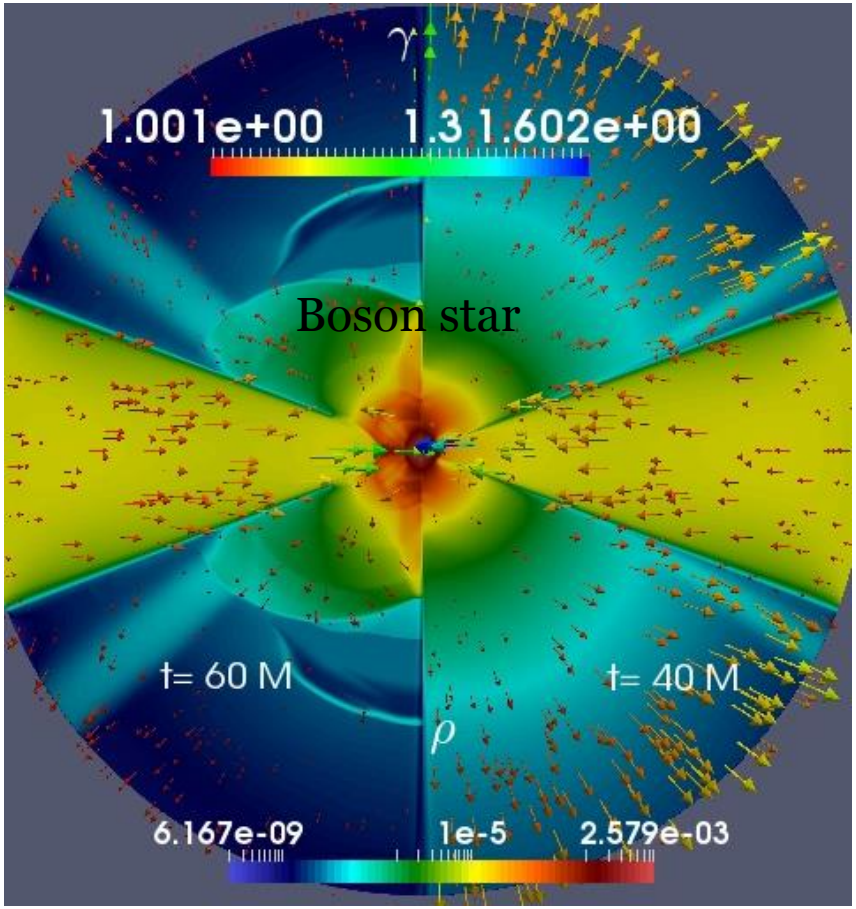


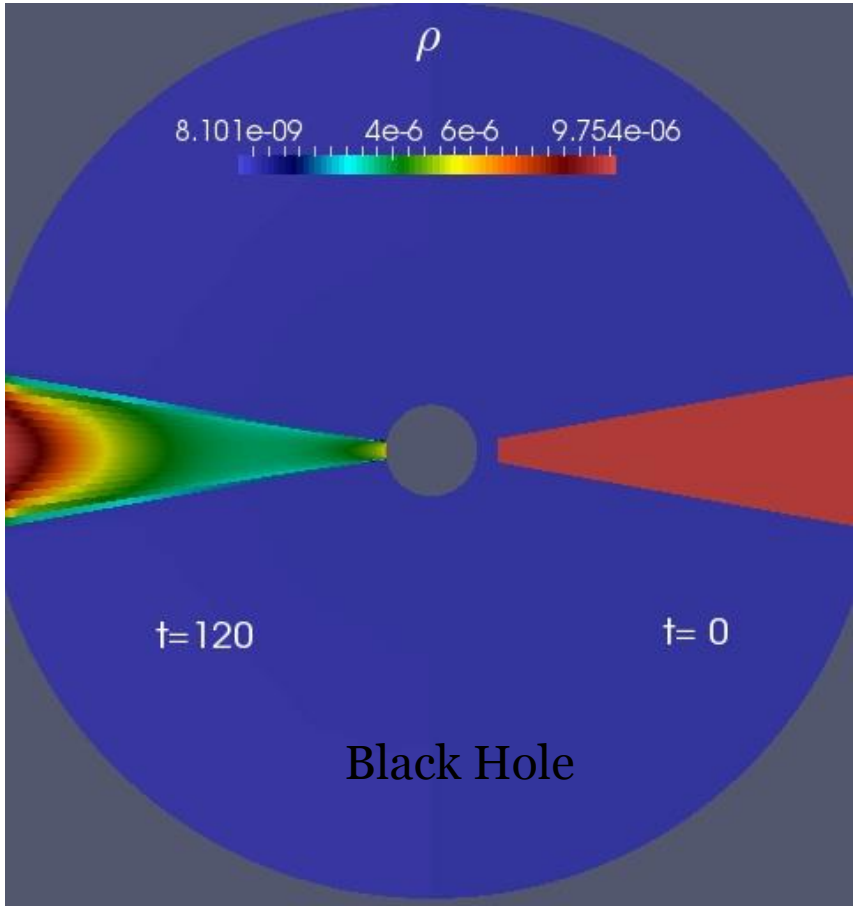


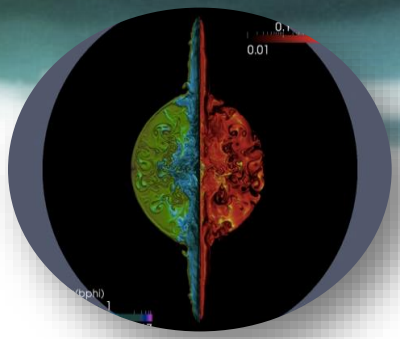
Evolve to intasble accretion-wind structure

Self gravity is neglected and we use polytropic equation of state.

Differences BS – BH accretion-wind







Conclusion

The thick torus around BS / BH have different proprieties

Spherical accretion rate on BS is limited