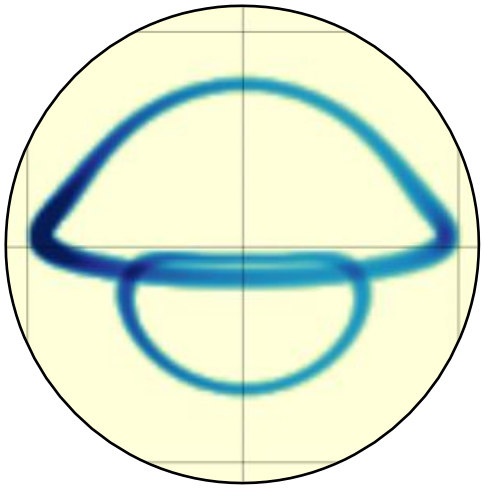
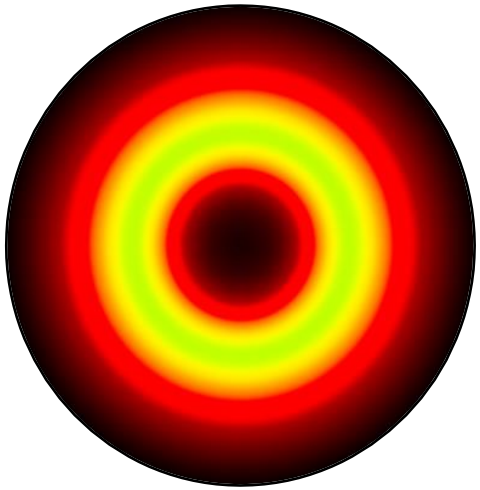
Recent developments on observational properties of bosonic stars from hot-spots and accretion disks





João Luís Rosa

In collaboration with:

V. Cardoso, P. Garcia, F. Vincent, D. Rubiera-Garcia

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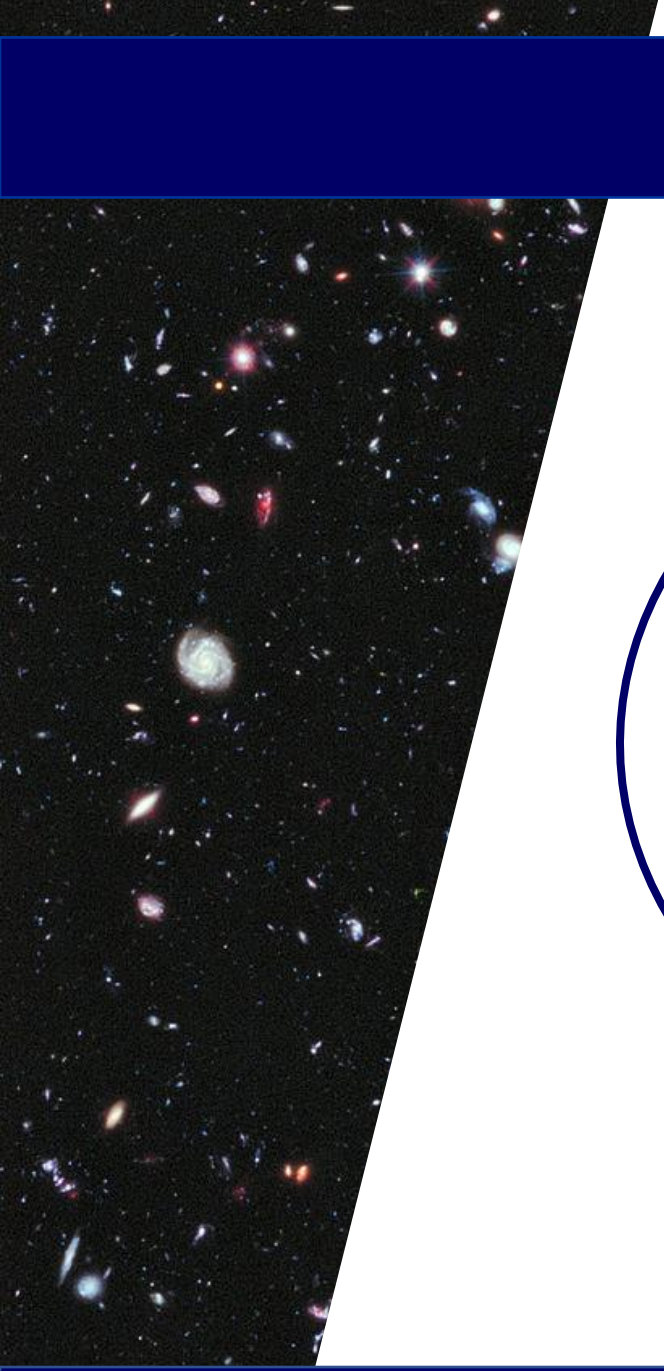
Mobilitas+

Eesti Teadusagentuur
Estonian Research Council



PART I

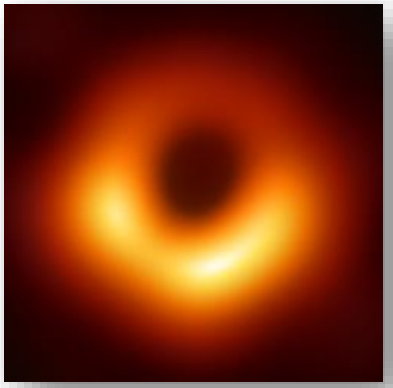
INTRODUCTION

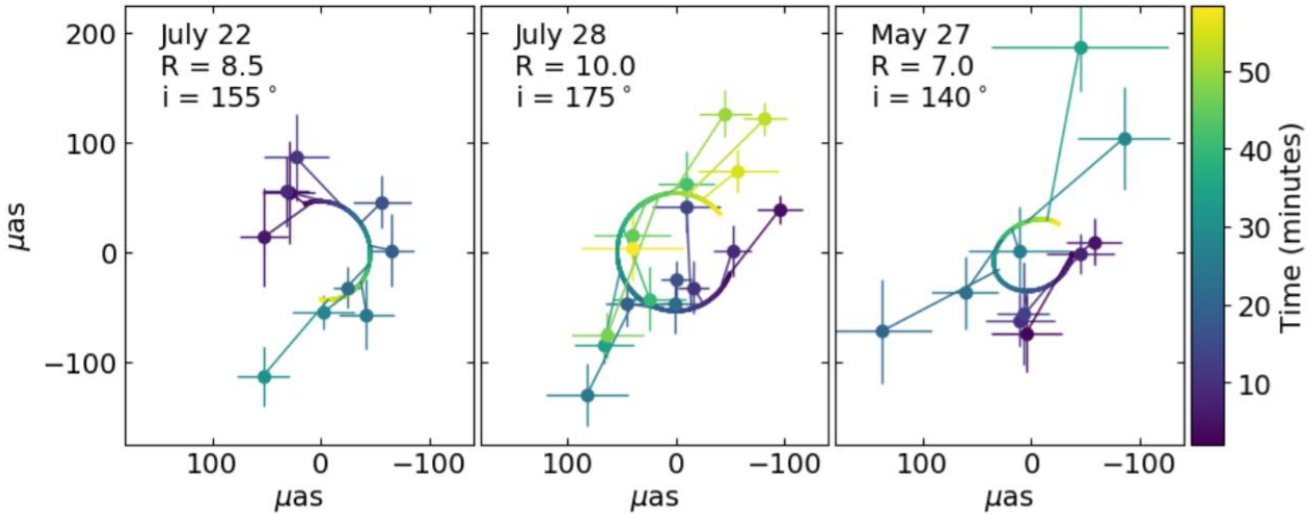
MOTIVATION

Recent observations indicate that objects which behave like **black-holes** exist

S2 Star orbit
ESO (2016)

M87 BH Shadow
EHT (2019)





Flares!
ESO (2020)

A&A 635, A143 (2020)

FRAMEWORK

Einstein-Klein-Gordon theory: addition of a complex and massive scalar field.

$$S = \int_\Omega \sqrt{-g} \left(\frac{R}{16\pi} - \nabla_a \Phi^* \nabla^a \Phi - \mu^2 \Phi^* \Phi \right) d^4x$$

Einstein-Proca theory: addition of a complex and massive vector field.

$$S = \int_\Omega \sqrt{-g} \left(\frac{R}{16\pi} - \frac{1}{4} F^*_{ab} F^{ab} - \frac{1}{2} \mu^2 A^*_a A^a \right) d^4x$$

Look for solutions with the following characteristics:

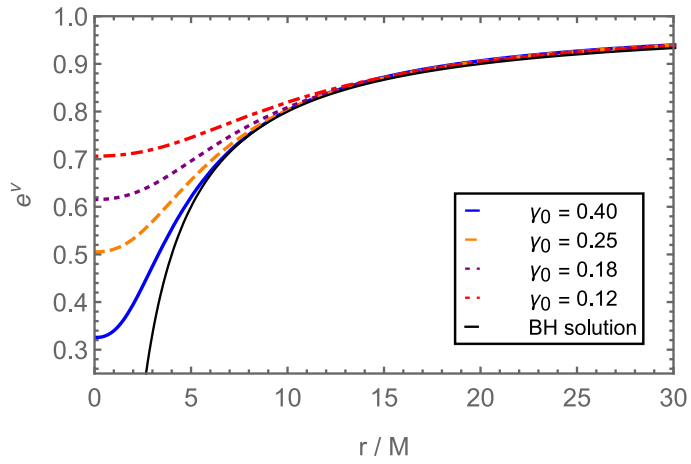
1. Spherically symmetric
2. Localized bosonic fields

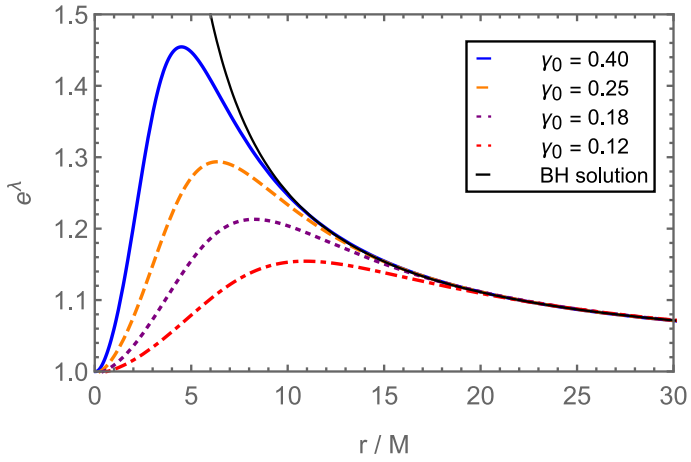
$$\left(\Box - \mu^2 \right) \Phi = 0$$

$$\nabla_b F^{ab} = \mu^2 A^a$$

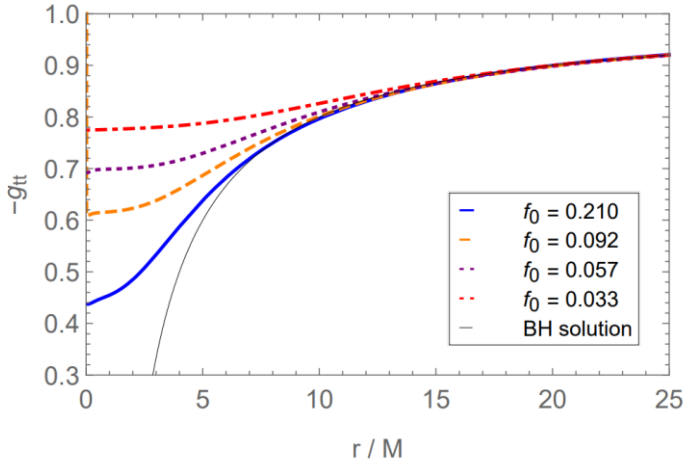
SPACETIME METRICS

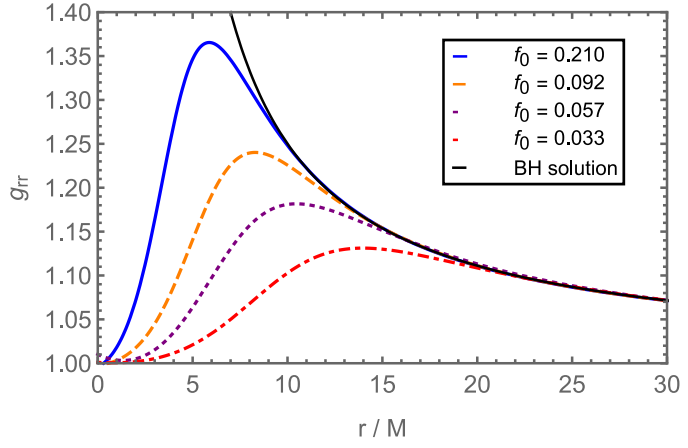
Boson star

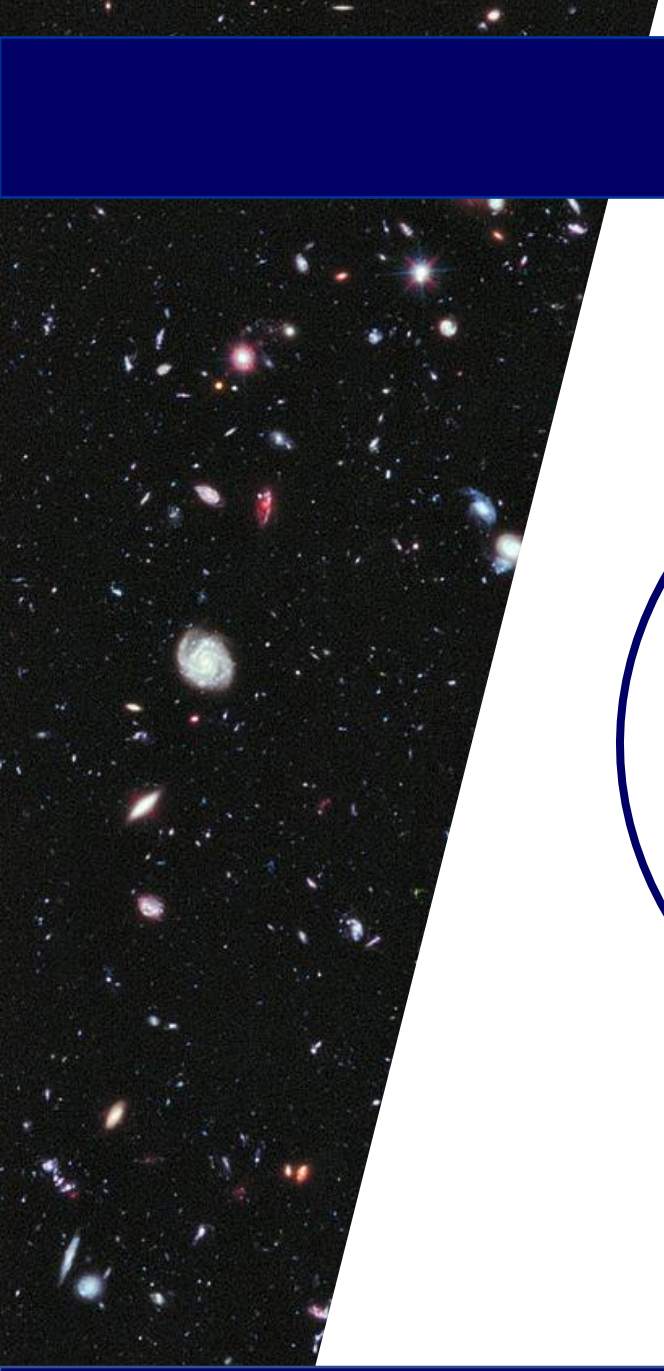




Proca star



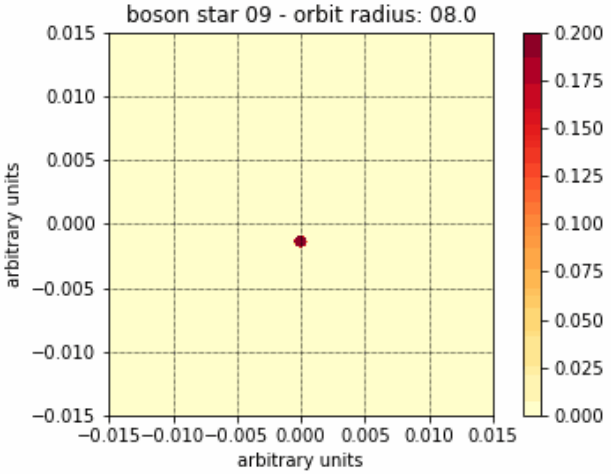


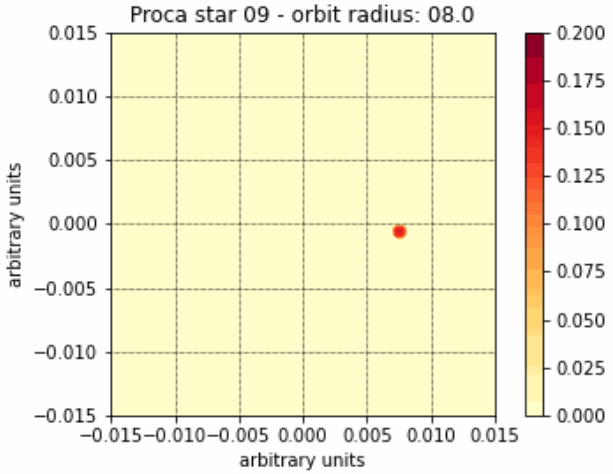


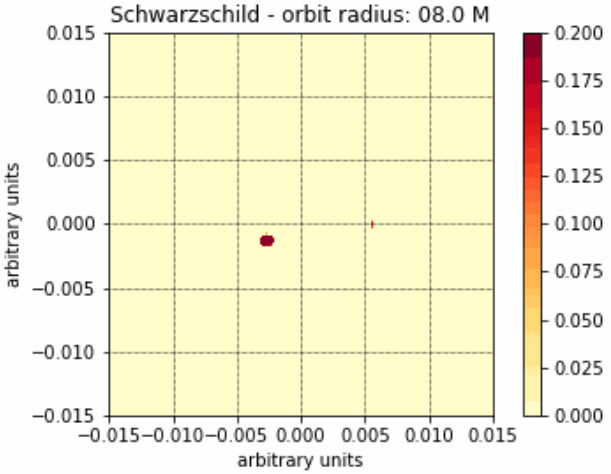
PART II

ORBITAL MOTION

EXAMPLES OF ORBITS





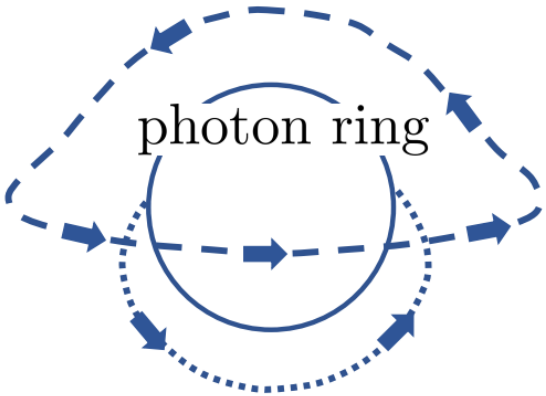


Main differences:

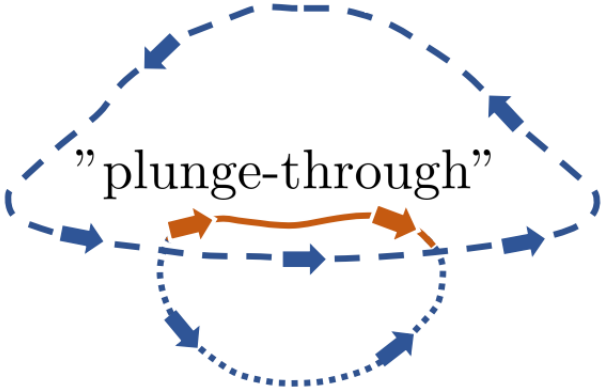
1. Apparition of third image
2. Different image shapes
3. Different flux intensities
4. Different deflection angles

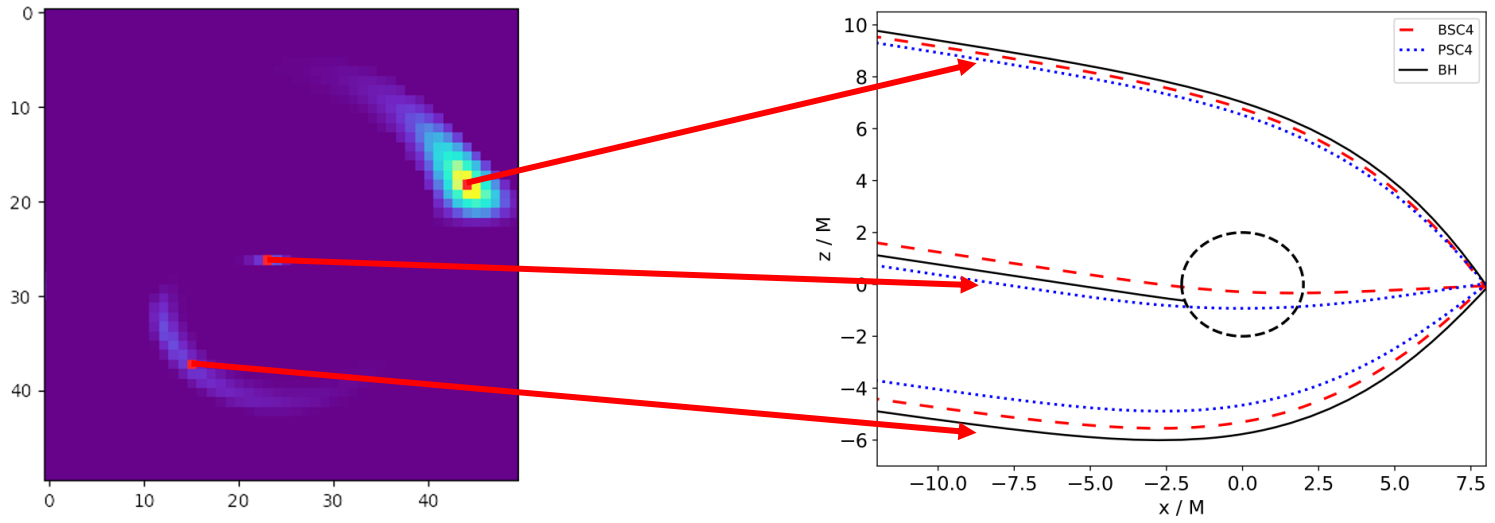
GEODESICS

Black Hole

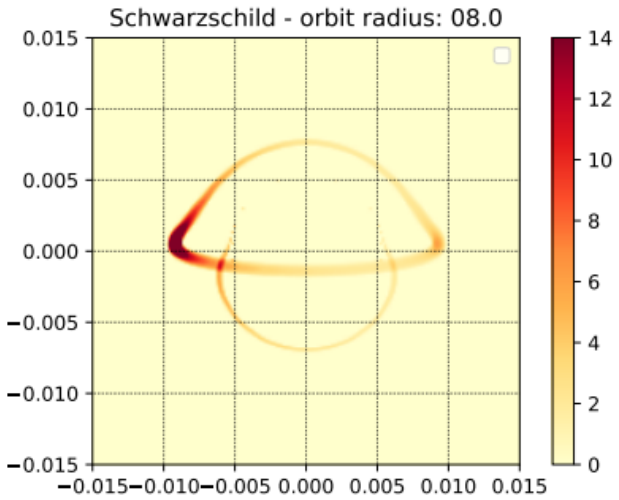


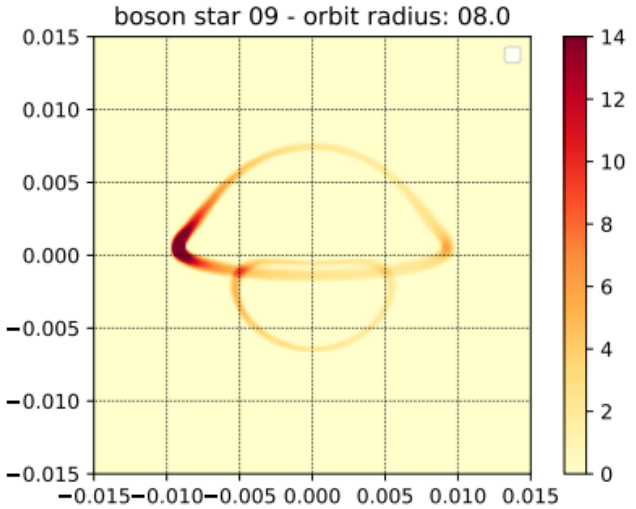
Boson star

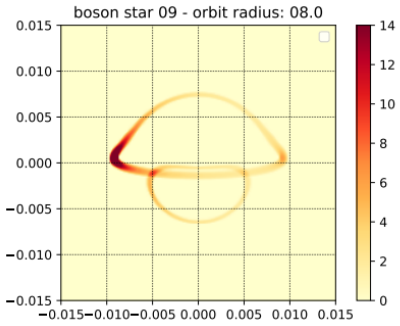


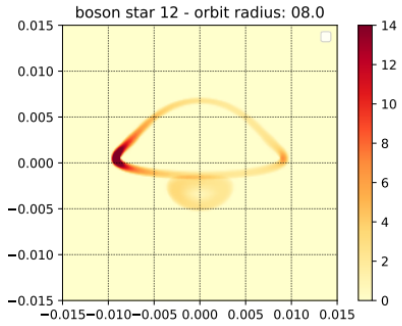


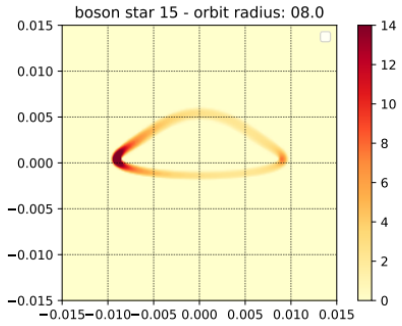
INTEGRATED FLUX

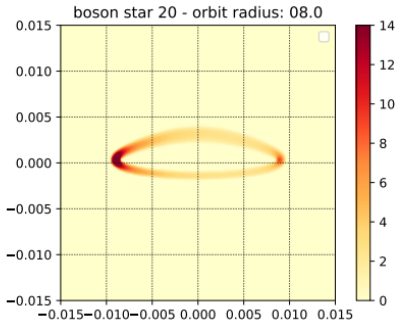




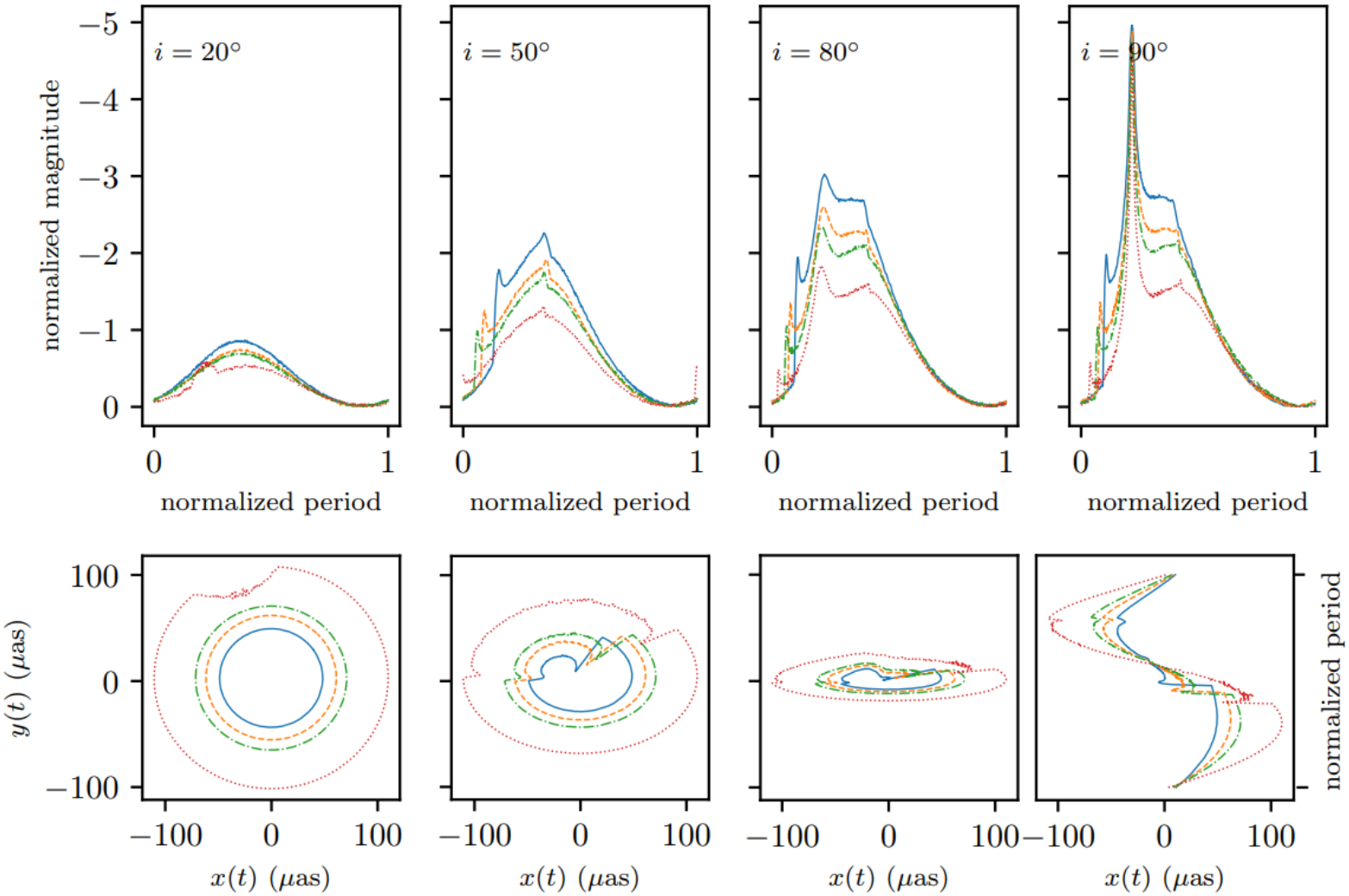


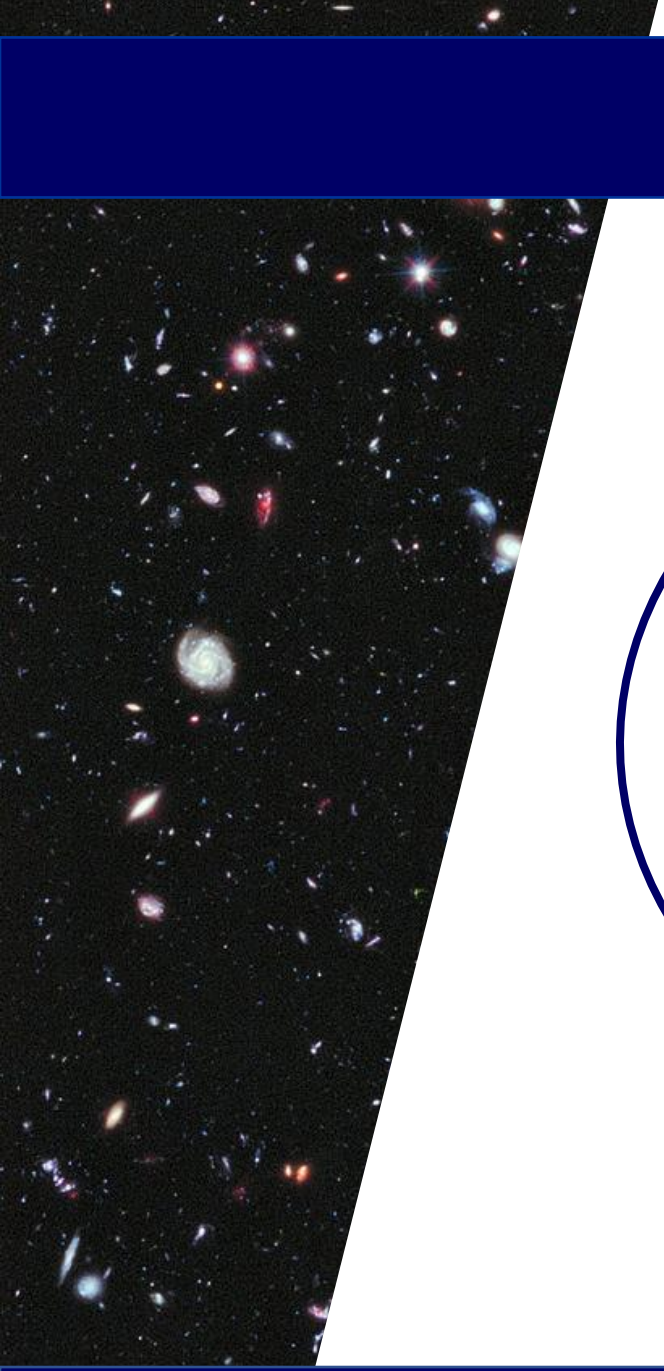






MAGNITUDE AND CENTROID

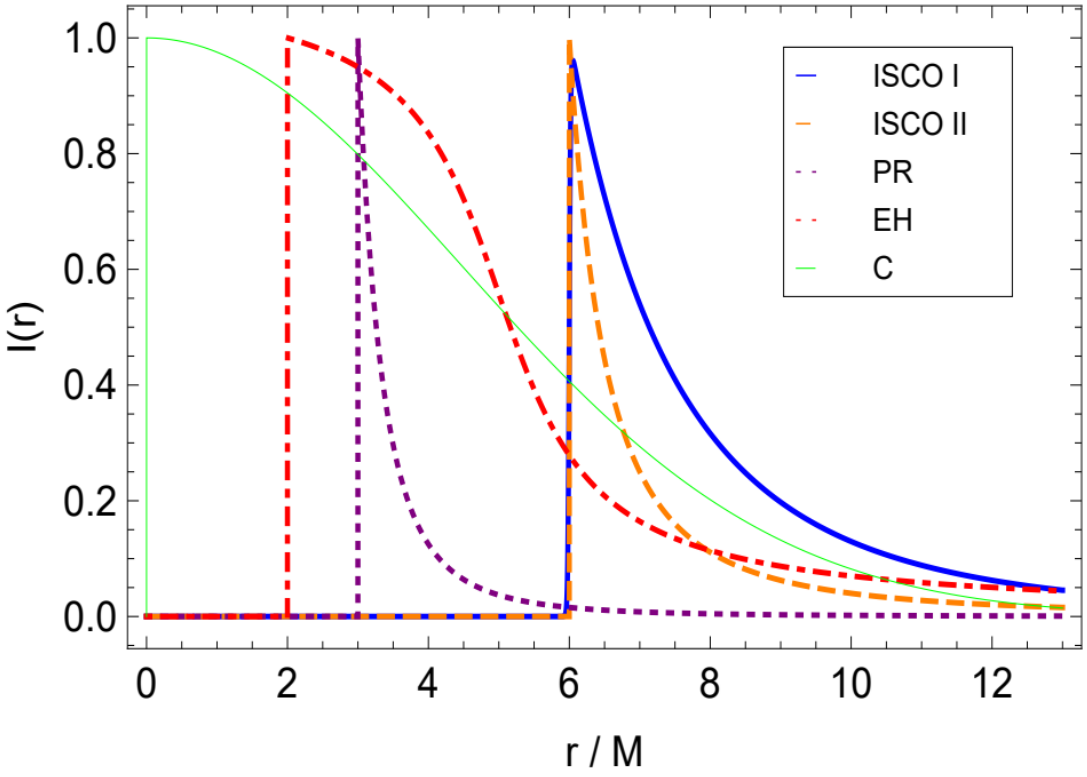




PART III

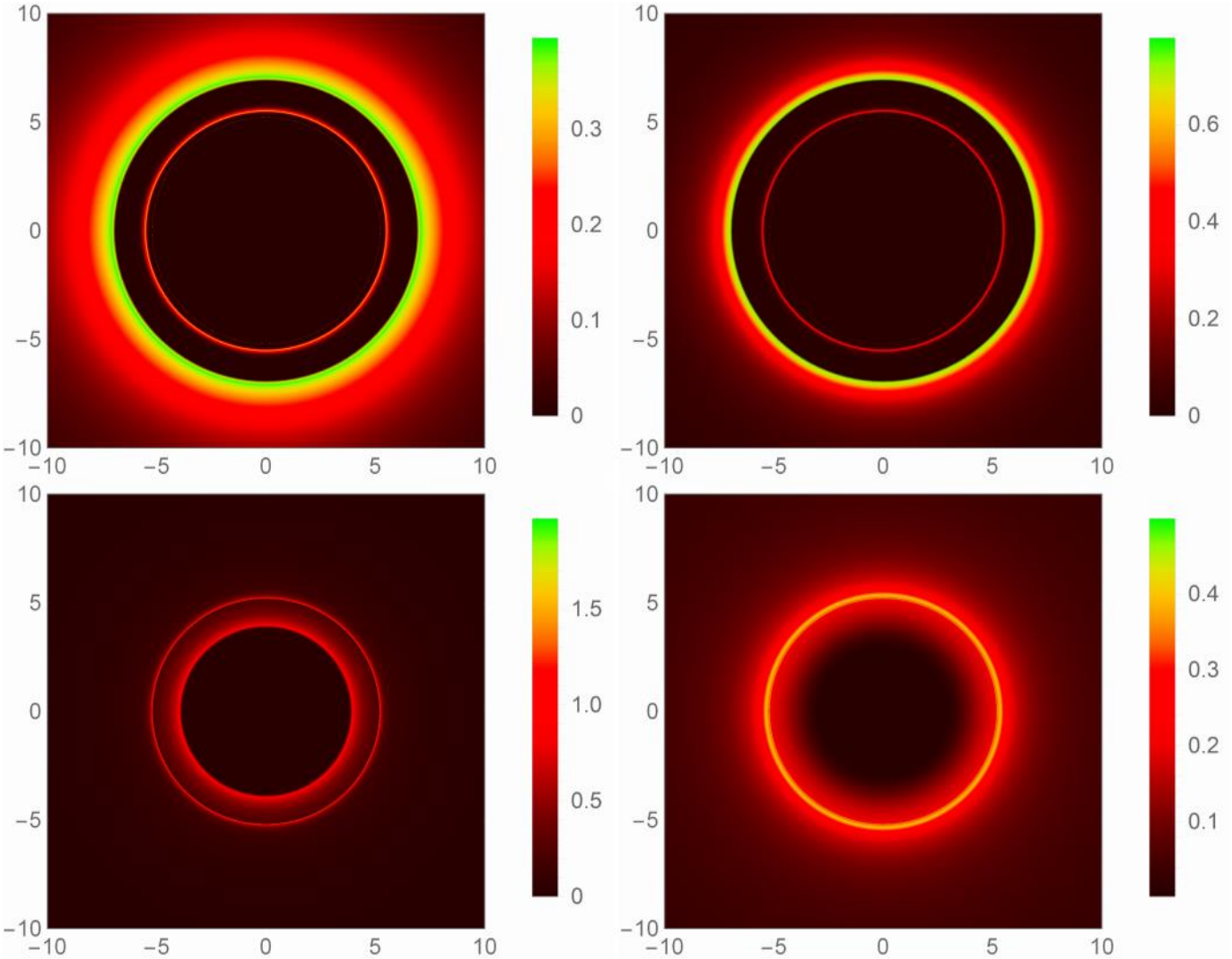
ACCRETION DISKS

ACCRETION DISKS

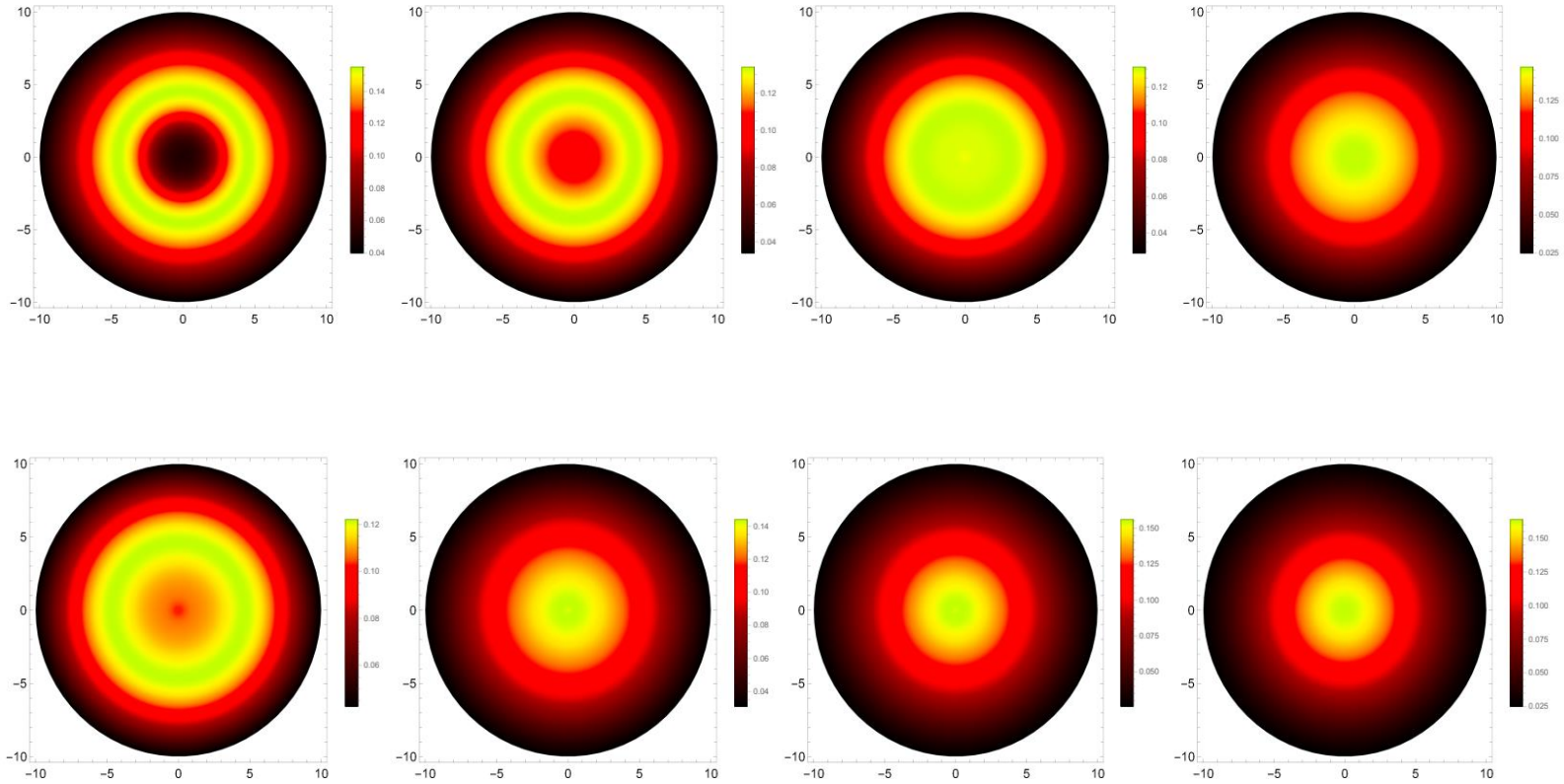


Accretion disk models: Relevant surfaces in BH spacetimes

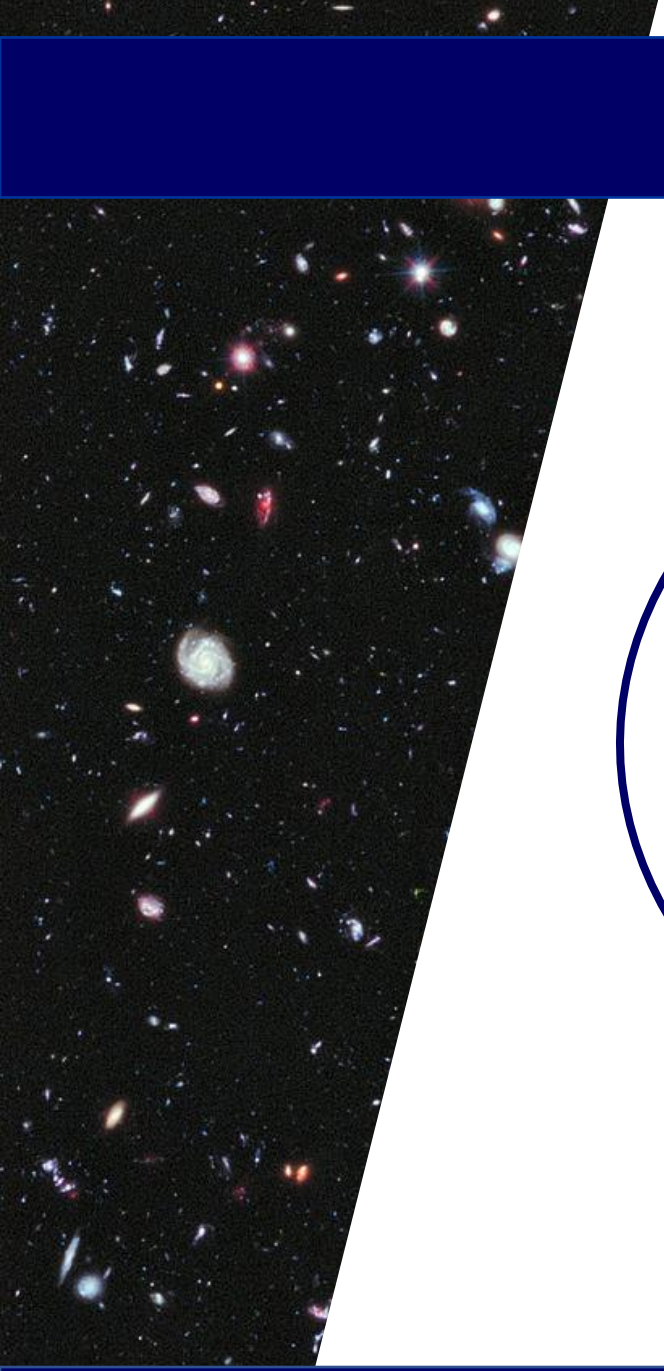
BLACK HOLE SHADOWS



REDSHIFT SHADOWS



Top row: Boson stars; **Bottom row:** Proca stars



PART IV

CONCLUSION

SUMMARY

ORBITAL MOTION

1. Astrometric observations can test the BH hypothesis;
2. Horizonless objects feature a plunge-through image;
3. Appearance of secondary image depends on inclination;

ACCRETION DISKS

1. Shadow observations can test the BH hypothesis;
2. Main difference between models is the absence of a light-ring;
3. Gravitational redshift can produce shadow-like features;

ONGOING WORK

1. Comparison of models with experimental observations;
2. Extension to more complex ECOs and disk models;
3. Inclination might resolve model degeneracy in shadows;

PUBLICATIONS INCLUDED

Orbital motion
arxiv:2205.11541

Accretion disks
arxiv:2204.12949

THANK YOU FOR YOUR ATTENTION