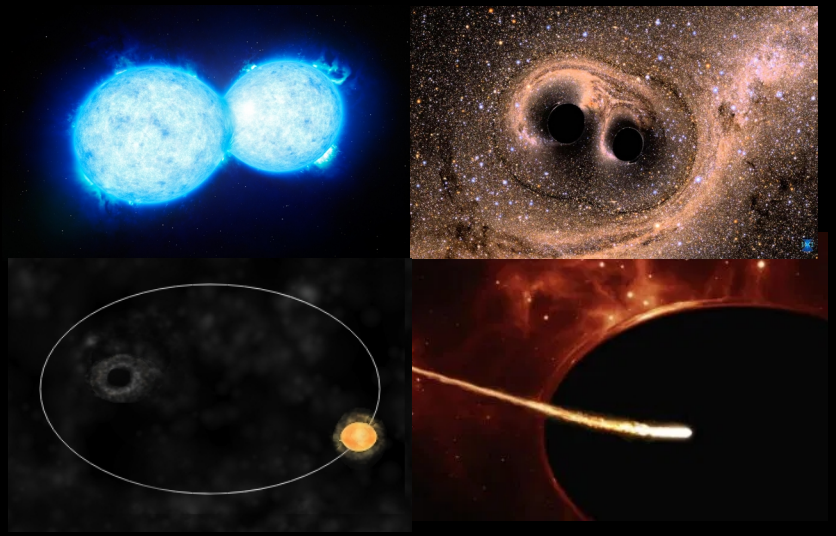
From Binary Stars to Gravitational Wave Sources and Other Black Hole Populations.

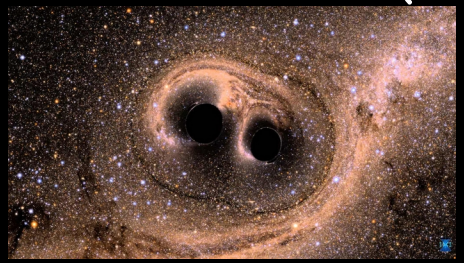


Aleksandra Olejak

now **Postdoctoral Fellow, MPA Garching** →from Oct. 26 **Tenure-Track, CAMK Warsaw**

My research focus: Binary systems with black holes

Black hole mergers -
Gravitational waves (LVK)



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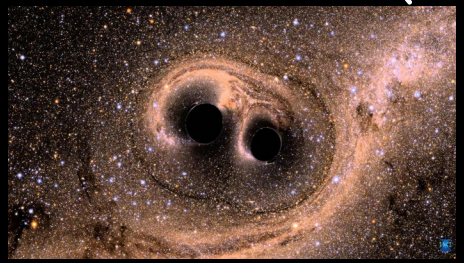
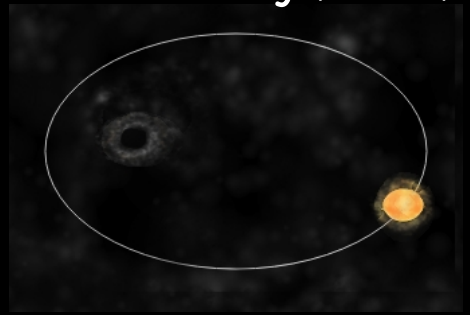


Dormant black holes -
Astrometry (GAIA)



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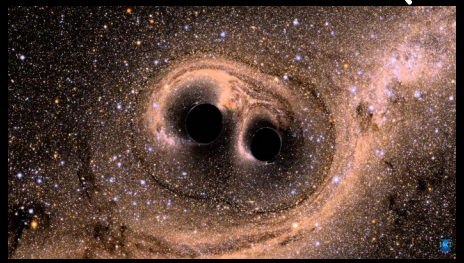

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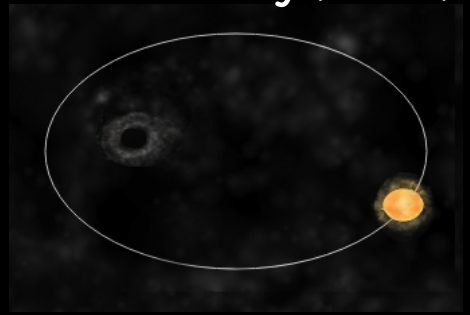
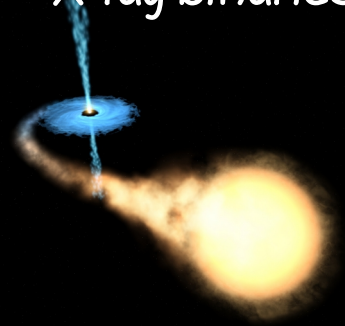


Accreting black holes -
X-ray binaries



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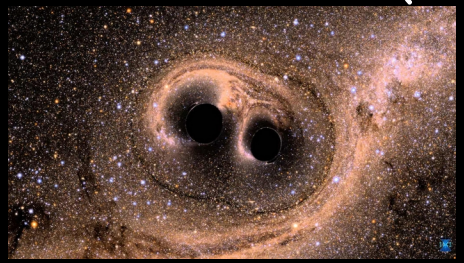

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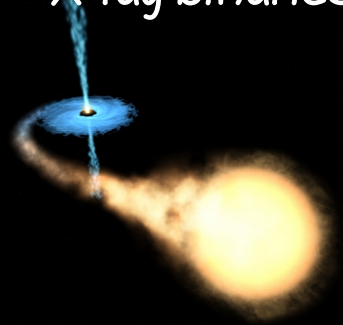

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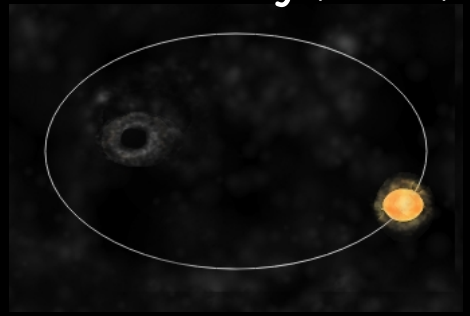

Partial tidal disruptions - Multimessenger (LISA)

My research focus: Binary systems with black holes

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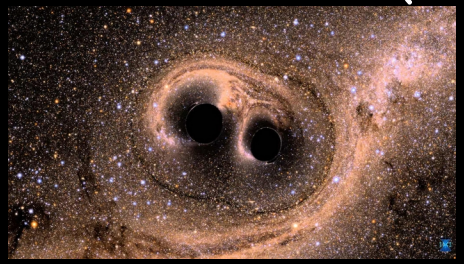
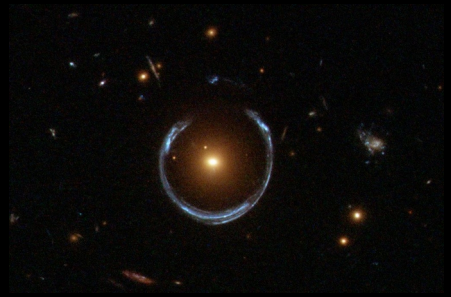


Isolated black holes - Microlensing



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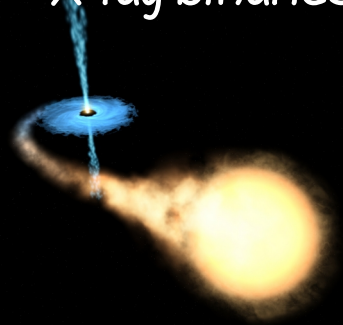

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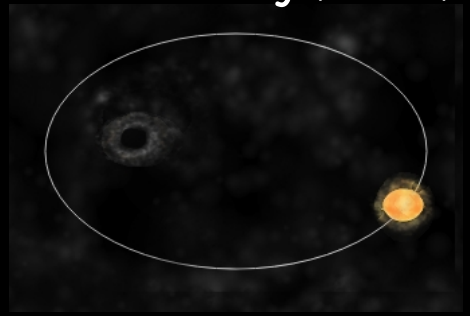

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Why binary systems matters?

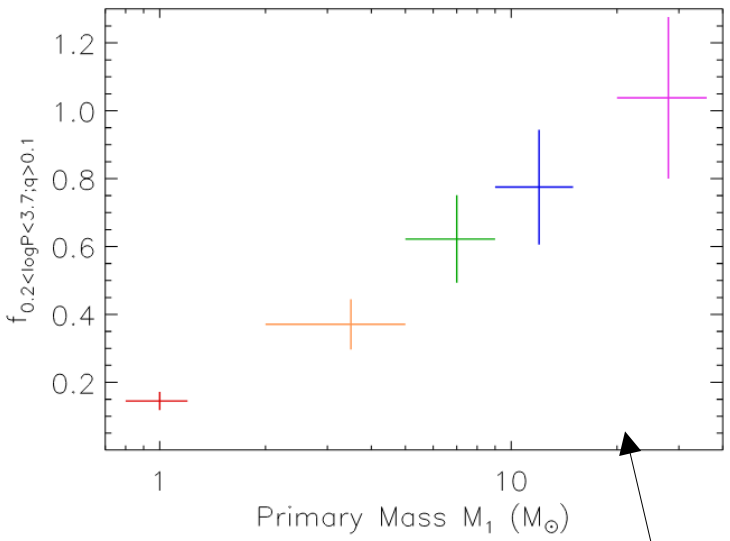

Fig. The frequency of companions as function of primary, adopted **Moe et al. 2017.**

Black hole progenitors

- Massive stars above 20 Msun (black hole progenitors) **always have companions**

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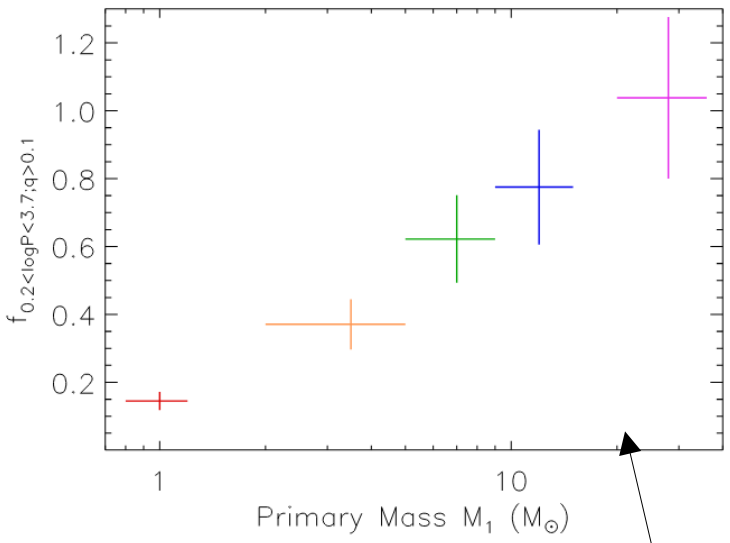

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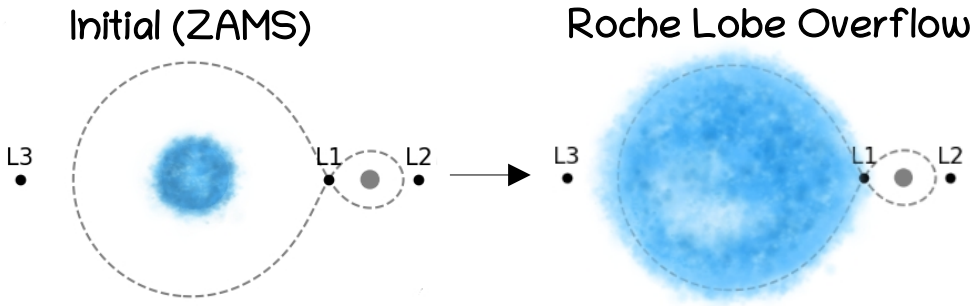

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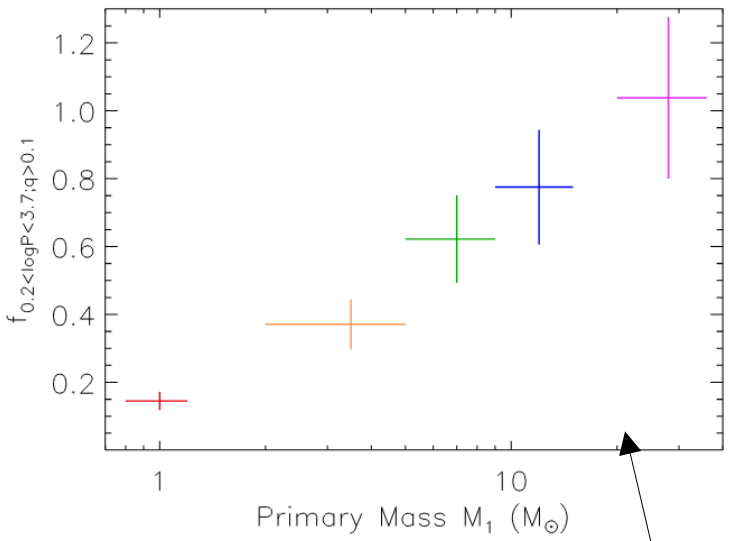

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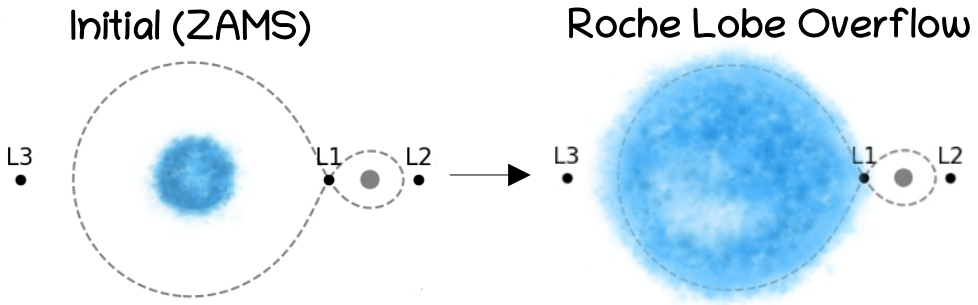
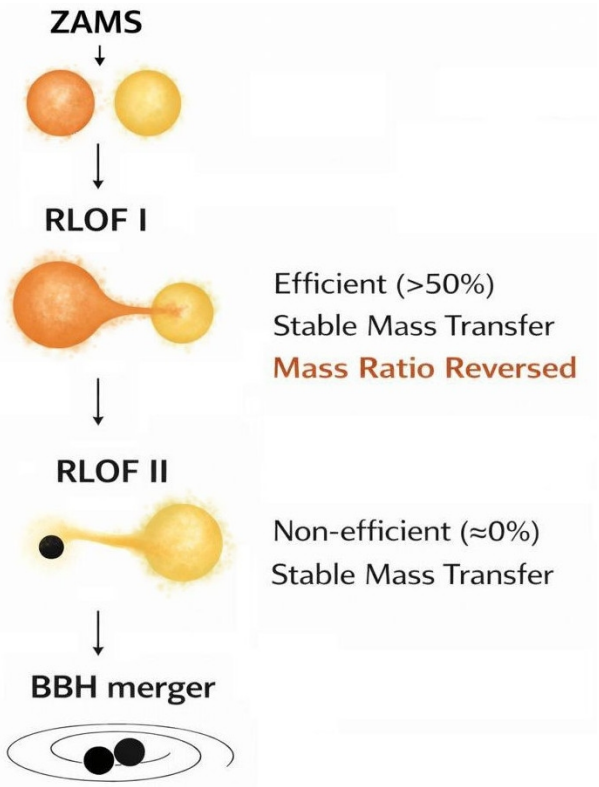


- Mass transfer (un/stable; non-/conservative) **determines the outcome**: final binary masses, separation and black hole spin.

Why binary systems matters?

Implications: e.g., formation of gravitational wave mergers



e.g., Olejak & Belczynski 2021, Olejak et al. 2022, 24,

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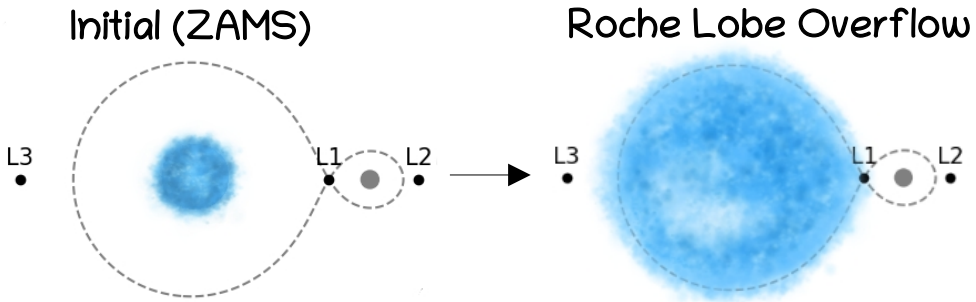

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Method: stellar evolution codes

Simulate evolution of binary systems for given initial conditions from ZAMS to the compact object formation.

Two type of codes:

Population Synthesis + Star Formation History
e.g. StarTrack, COMPAS

+big populations of Galaxy/local Universe
+event rates

-based on fits to detailed codes

Detailed Stellar Evolution Codes
e.g., MESA

+stellar structure
+angular momentum
+mass transfer

-time consuming
-small grids, individual systems

Big questions
(selected highlights)

What is the origin of gravitational wave (GW) sources?

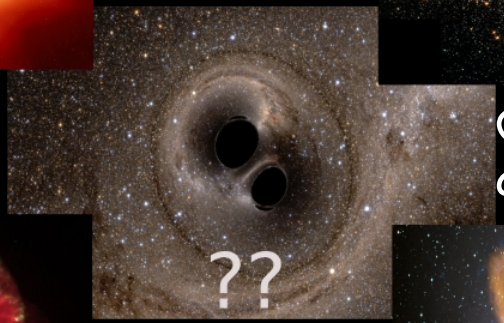
After ~10 years we have:

~200 (+100 candidates) detections
-mass and spin distributions
-correlations between parameters

What can we learn about astrophysics of binary systems?

Binary systems

Triples and other multiples



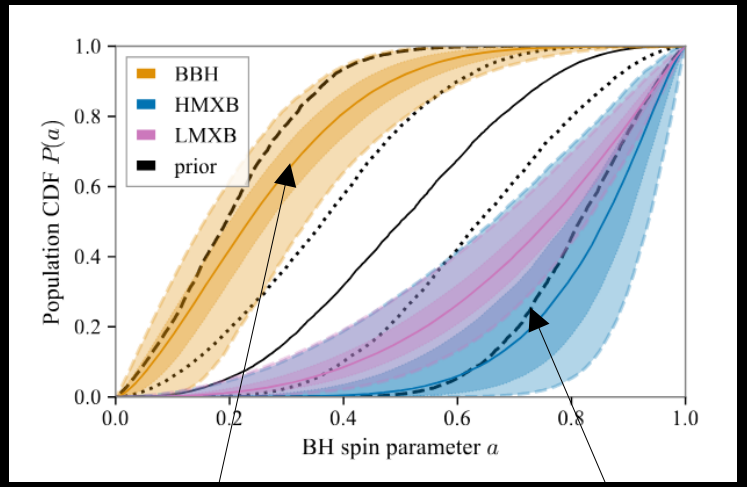
Globular clusters

Other: AGNs, primodial

Black Hole Spin controversy

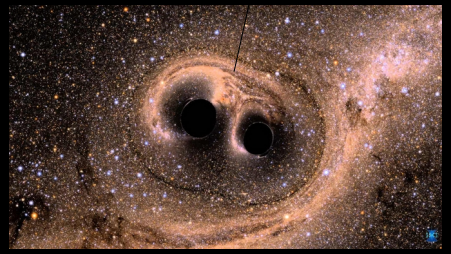
Merging black holes have **low spins: a~0.0-0.2.**
Black holes observed in X-ray binaries have **very high spins: ~0.7-0.9**

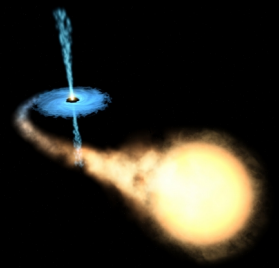
Fishbach & Kalogera 2022



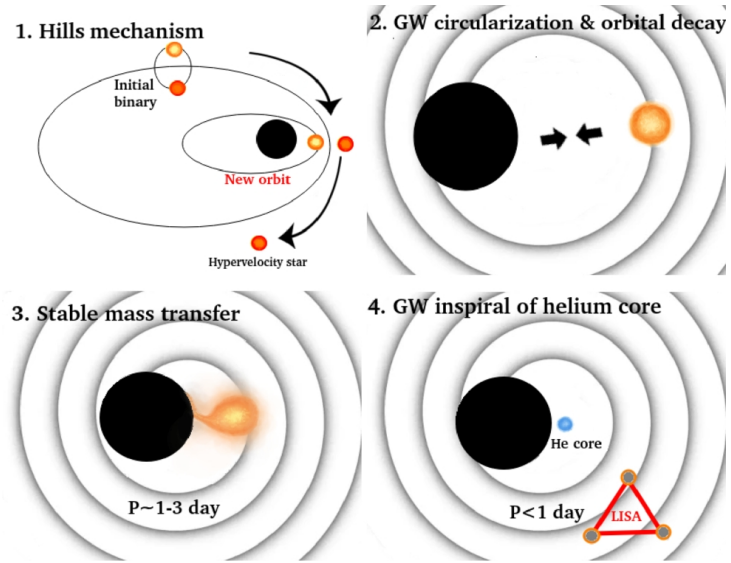
What is the origin of the tension - binary evolution or wrong measurements?

Possible PhD offer in collaboration with Prof. A. Zdziarski, CAMK PAN





What happens to a star that gets too close to SMBH & IMBH?



Olejak et al 2025

1) dynamical formation of binaries of stars and SMBH/IMBH

2) circularization of the system

3) stars undergo mass transfer - sometimes it happens inside the LISA frequency band

4) possible new type of multimessenger source

In collaboration with:

Ismael Brunet-Pac, TUM

Dr. Abbas Askar, CAMK PAN

Possible postdoc offer

Summary

From October 2026:

-bachelor/master thesis

-practices, e.g., summer 2027

Topics: **gravitational wave sources, dormant black holes - Gaia, X-ray binaries,**

Possibly later this year:

-PhD in **"black hole spin tension"**

-postdoc in **"star and massive black hole binaries as multimessenger sources"**

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