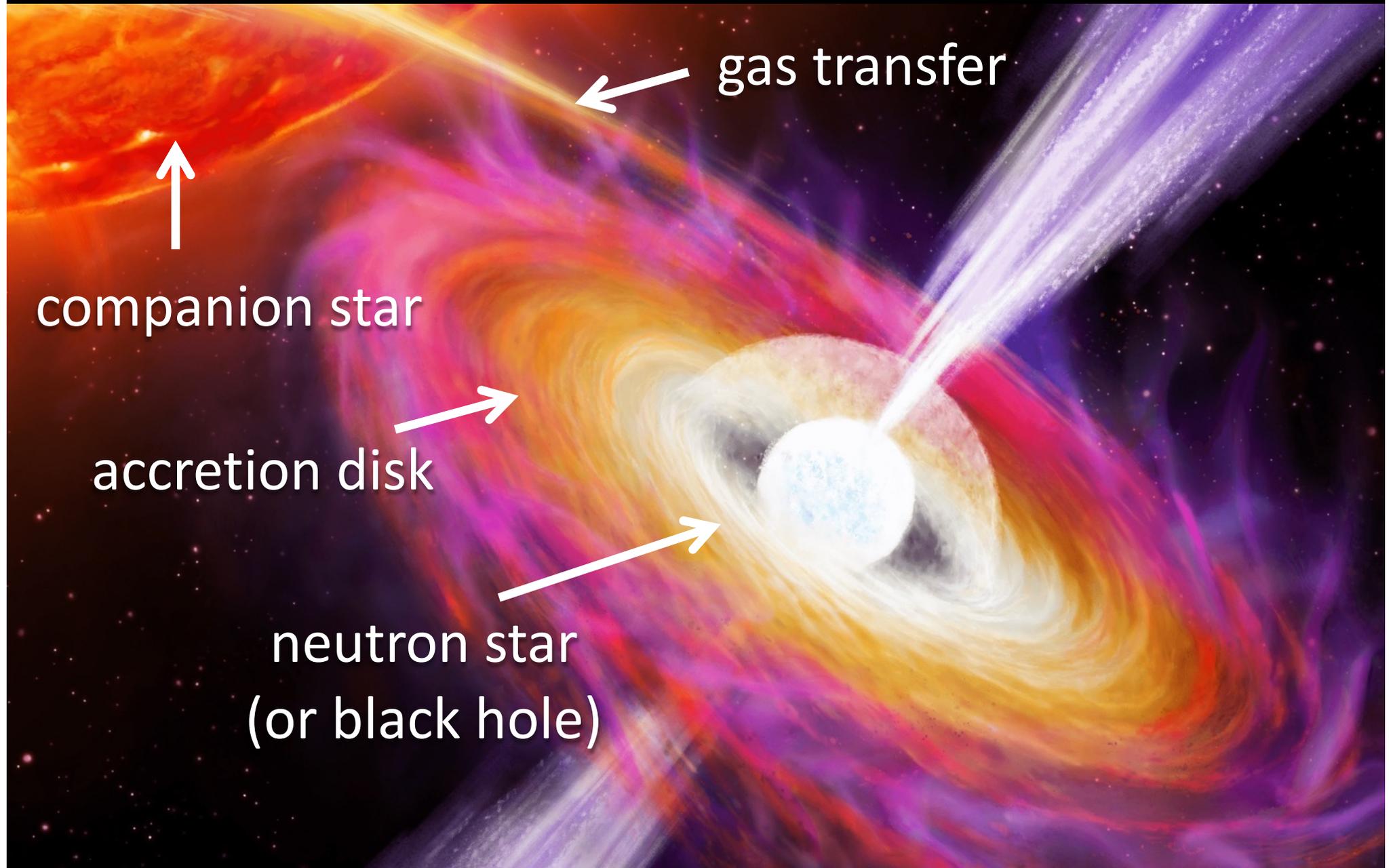


Cosmic Cannibals: X-Ray Binaries

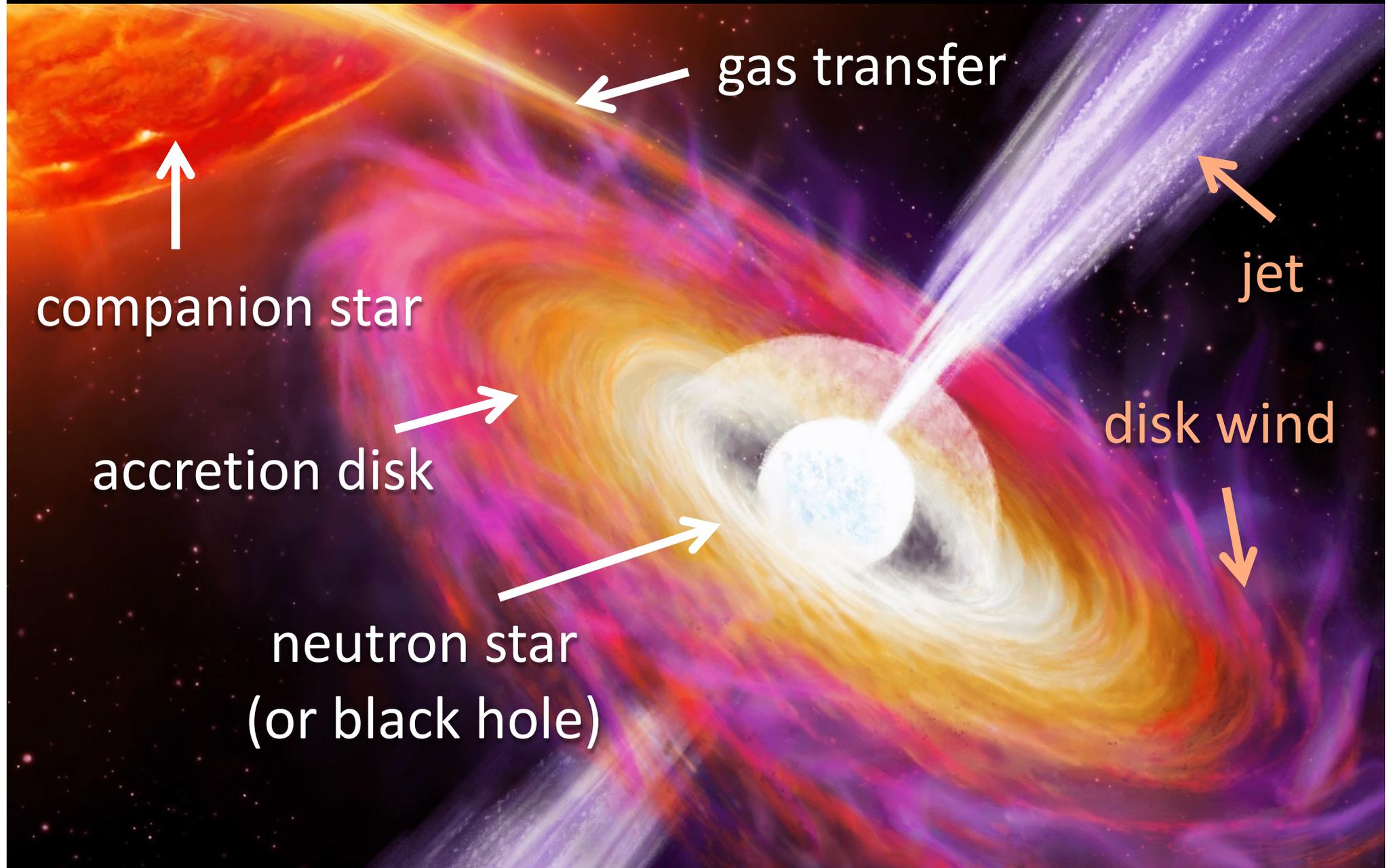


Nathalie Degenaar
C4.120

Anatomy of an X-ray Binary



Anatomy of an X-ray Binary



Why We Study X-Ray Binaries

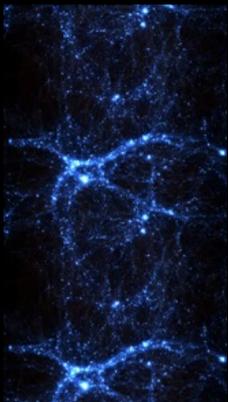
1. Black holes and neutron stars are fascinating!



Probe **extreme** physics

Involved in many **explosive** phenomena

2. Big role / impact in many areas of astrophysics



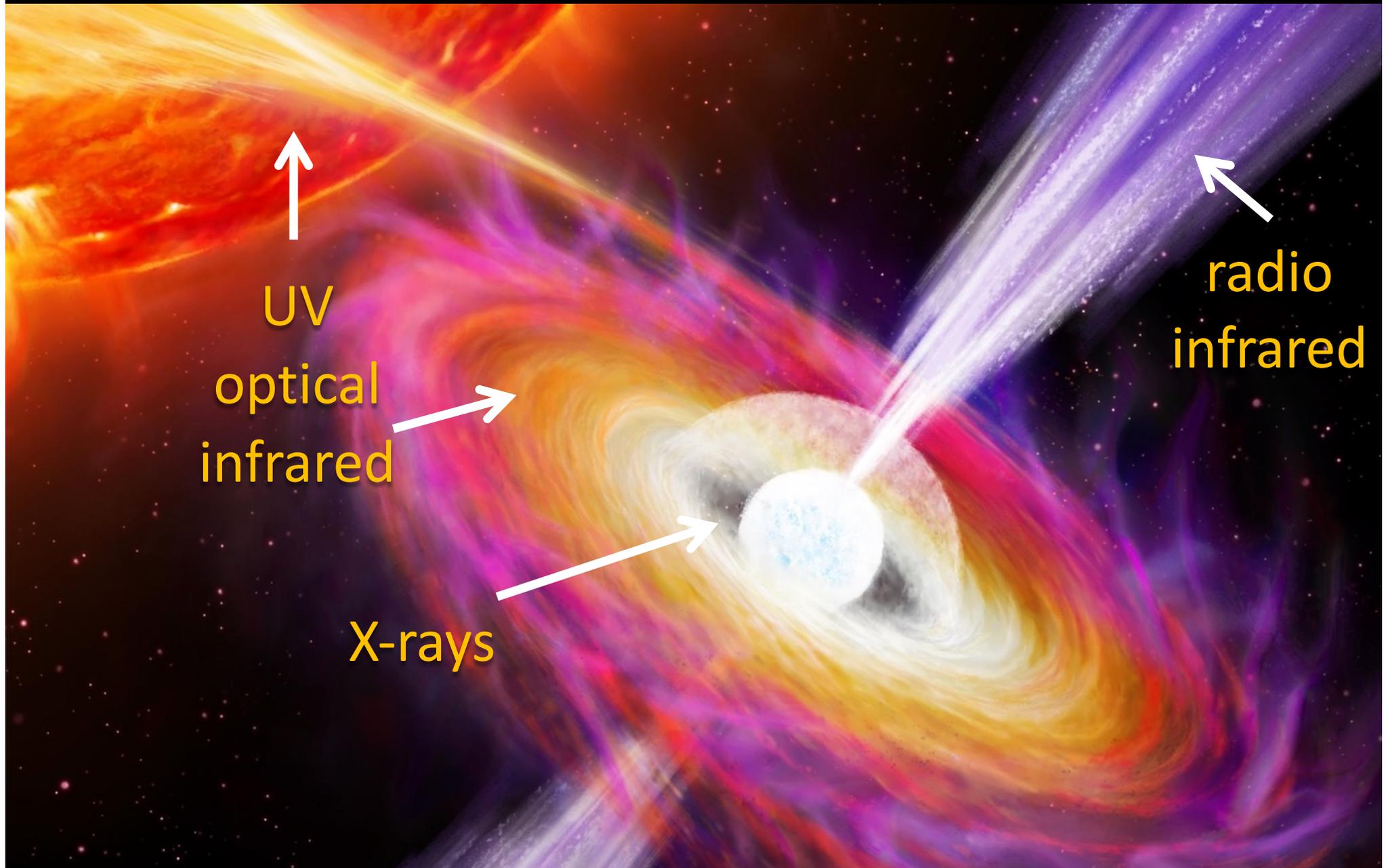
Progenitors of **gravitational wave** mergers

Enrich the universe with **exotic particles/atoms**

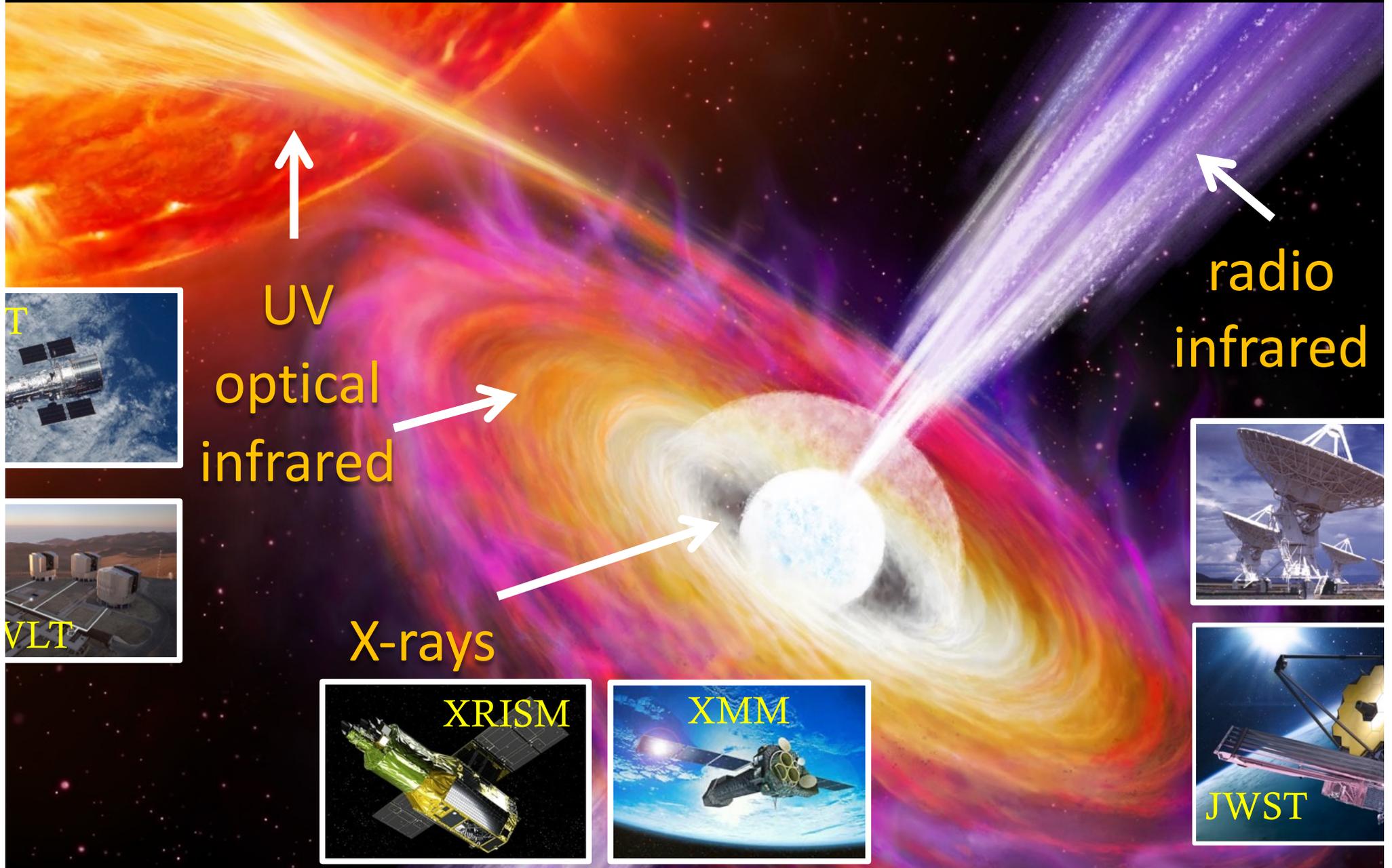
Impact **evolution** of galaxies

....

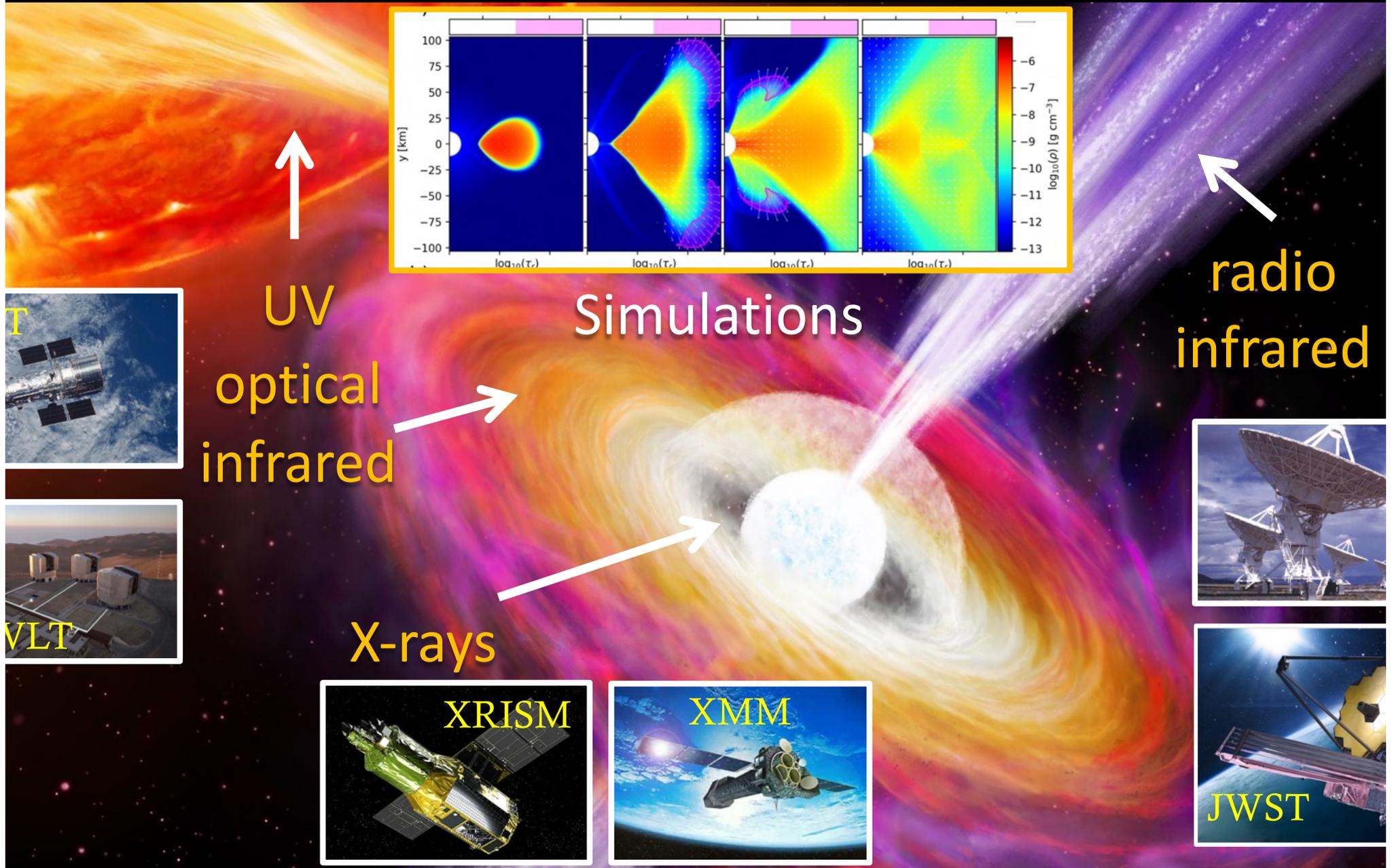
How We Study X-Ray Binaries



How We Study X-Ray Binaries



How We Study X-Ray Binaries



Who is in the Group



Nathalie
API staff



Julia
postdoc



Andres
Marie Curie fellow



Chuanyu
PhD yr-1



Simo
PhD yr-1



Ylvie
MSc



Daan
MSc



Qianhang
MSc



Sara
PhD yr-1 @ ESO



Eleonora
PhD yr-3

MSc projects 2026-2027

I + II = Disk winds

III + IV = Jets

V = Impact on surroundings

Project I: New eyes on Disks (X-ray)

Disks and winds are *incredibly* important, but...

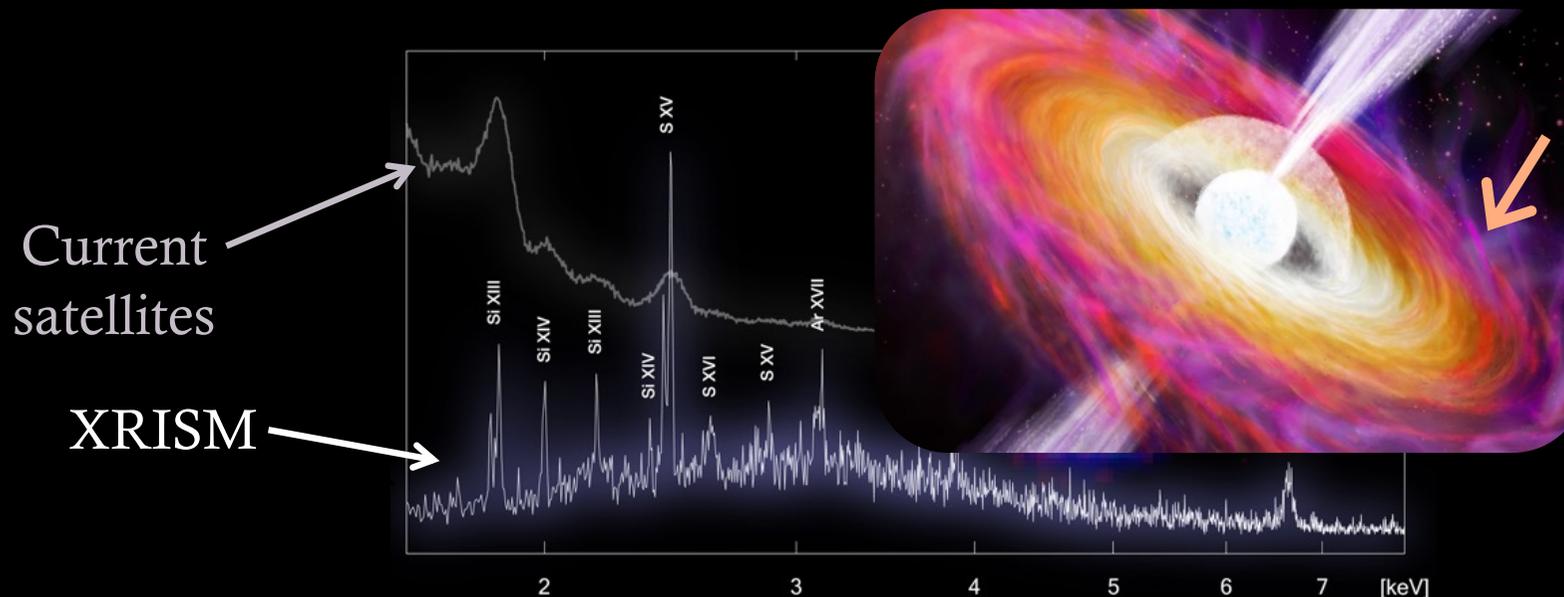


Key questions:

Structure of disks?

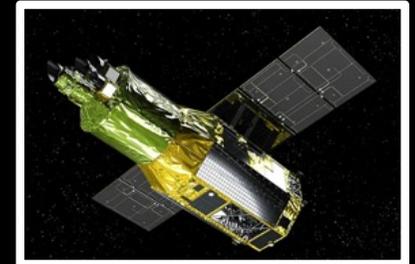
Density and speed of winds?

XRISM = revolutionary new X-ray satellite (2024)



Project I: New eyes on Disks (X-ray)

Data: XRISM + XMM-Newton



Analysis: X-ray spectra + light curves



Target: Famous neutron star Cygnus X-2

Joint project with:

Elisa Costantini (SRON, Leiden)



Maria Diaz Trigo (ESO, Germany)



Project intends to include a 1-month work visit to ESO



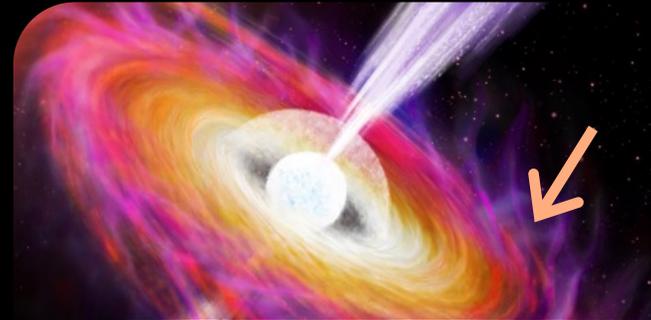
Project II: Winds of Change (UV)

Disk winds are *incredibly* important, but...

Key questions:

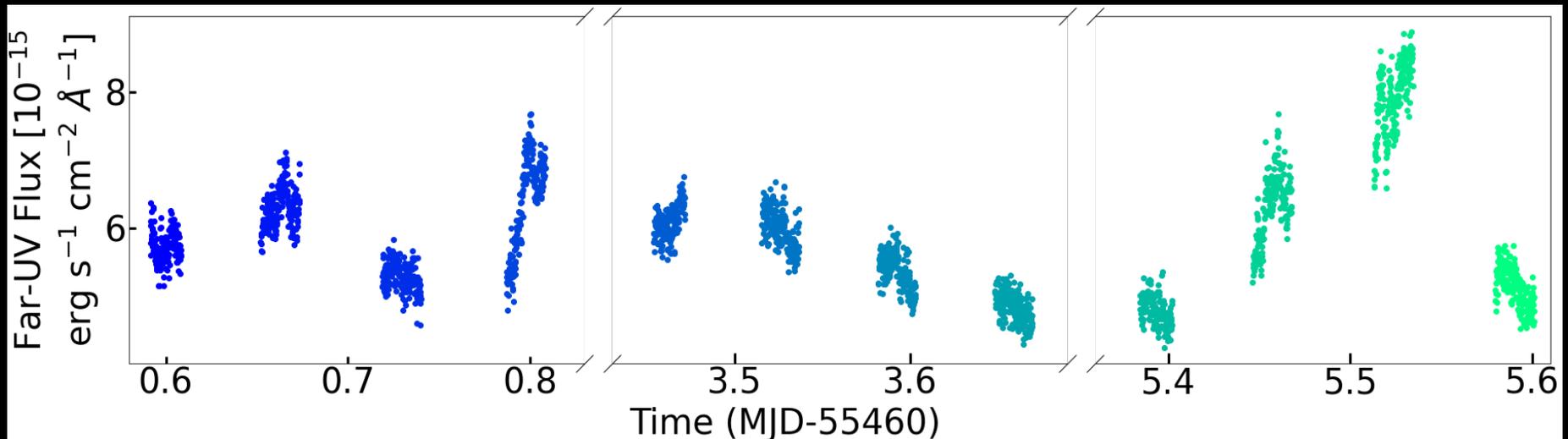
When do winds occur?

How much mass is blown away?



UV studies of winds = fully uncharted

→ Can we see a changing wind? Surprises await!





Project II: Winds of Change (UV)

Data: Hubble Space Telescope



Analysis: UV spectra + light curves

Target: Famous neutron star Cygnus X-2

Project led by:

Stefanie Fijma (ESO, Germany)



Project intends to include a 1-month work visit to ESO

Project III: Jet Speed



Jets are *incredibly* important in our universe, but...

Key questions:

What are their physical **properties**?
How are they **launched**?



Brand new technique

Correlated changes in different emission regions of the jet

→ Time difference allows you to **measure jet speed!**

This has not been possible before.
How fast are the jets? What sets the jet speed?

Project III: Jet Speed



Data: Very Large Array

Analysis: Radio data, timing techniques

Target: Famous neutron star Scorpius X-1



Project supervised by:

Eli Pattie (radio data ninja)



Project IV: Jets... in the lab!

Jets are *incredibly* important in our universe, but...

Key questions:

What *processes* occur *in jets*?
How related to jet properties?

New out-of-the-box approach:

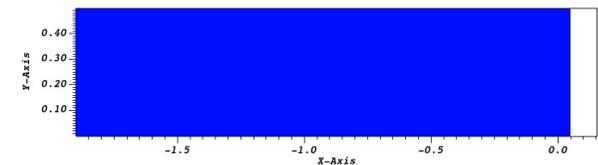
Reproduce *jets* in a laserlab

Current MSc project by Ylvie

Simulations of potential lab

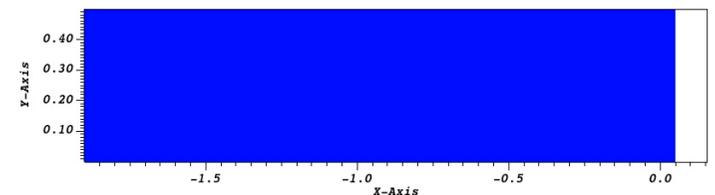
experiments!

laser shooting at tin sample



user: ylviegerritsma
Fri Feb 6 16:05:50 2026

plasma flowing out of tin
sample due to laser

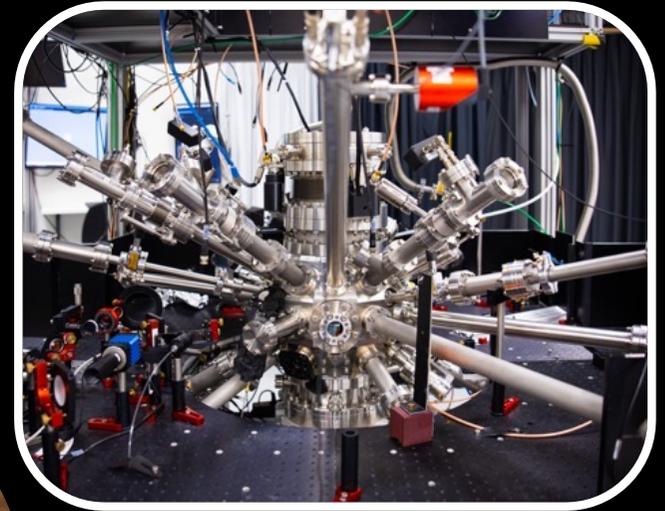


user: ylviegerritsma
Fri Feb 6 16:04:49 2026

Project IV: Jets... in the lab!

Different possibilities for follow-up:

- Plasma simulations
- Jet simulations
- Laser experiments



Joint project with:

Oliver Porth (API)



John Sheil (ARCNL)



Oscar Versolato (ARCNL)



Project V: Jet Impact

Jets are *incredibly* important in our universe, but...

Key questions:

How much **power** is in jets?

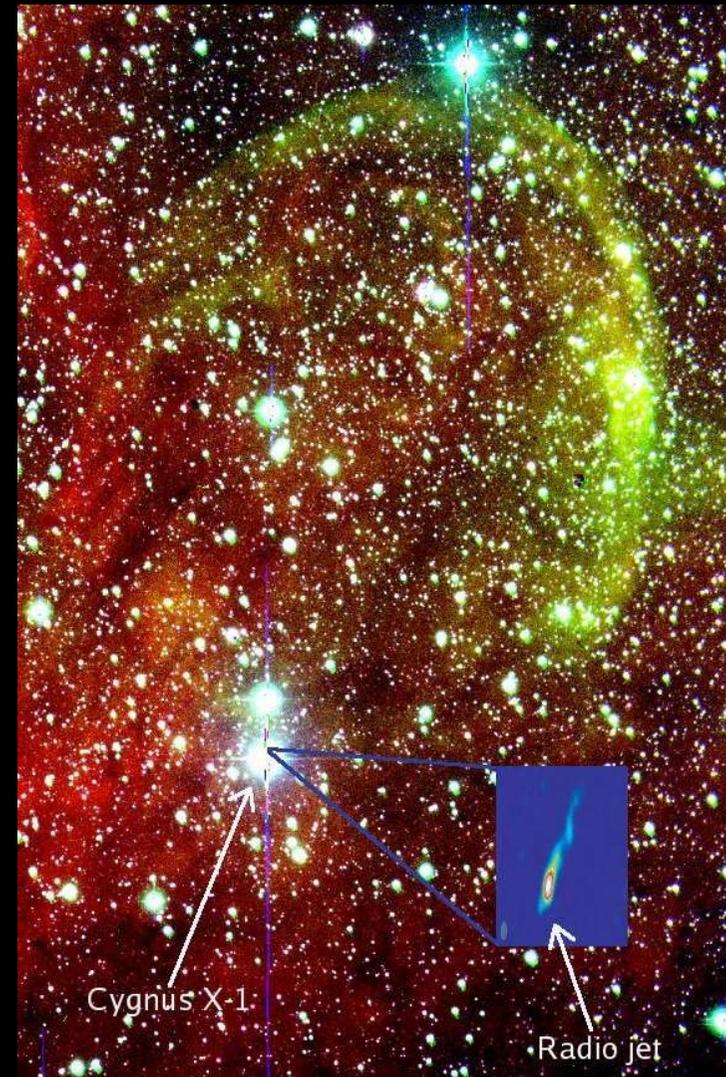
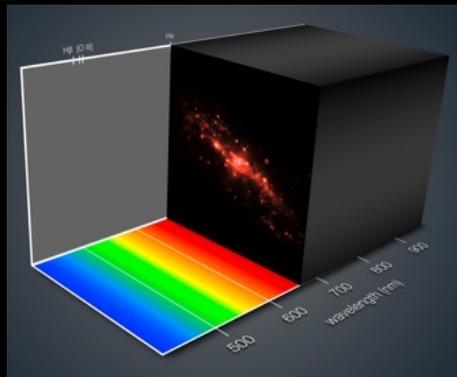
How are they **launched**?

Opportunity:

Impact the interstellar medium

Spectroscopy of impact region →

measure jet power!



Project V: Jet Impact

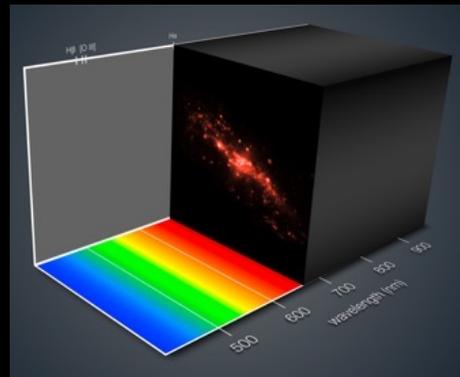
Data: Very Large Telescope

Analysis: Optical data, signal processing

Target: Hyper-active black hole MAXI J1820

Project supervised by:

Andres Gurrpide-Lasheras



Project X: Build Your Own

THE **PROJECT** YOU'VE ONLY
DREAMED ABOUT



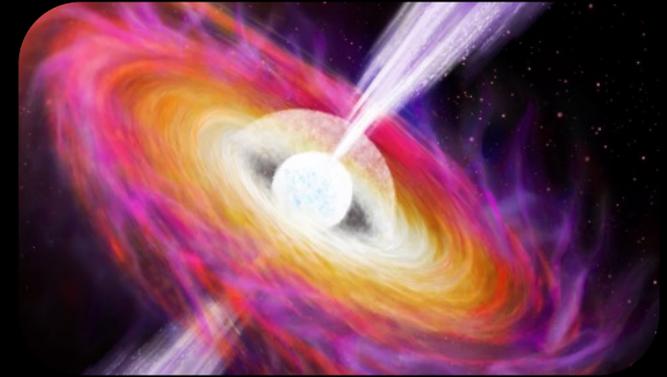
PROJECT X

A **tailored project** is also possible

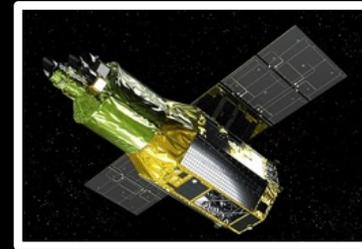
Check out my website for ideas of research done in my group

Summary

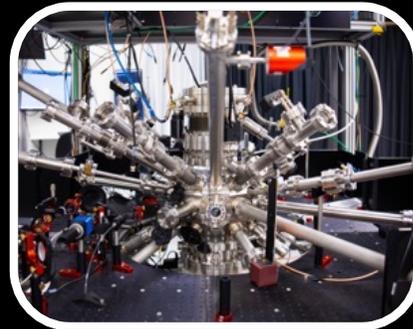
I. **Disks** through eyes (**ESO**)
(X-ray data)



II. **Winds** of change (**ESO**)
(UV data)



III. **Jet** speed
(radio data)



IV. **Jets** in the lab (**ARCNL**)
(simulations or experiments)

V. **Jet** impact
(optical data)



BYO PROJECTX



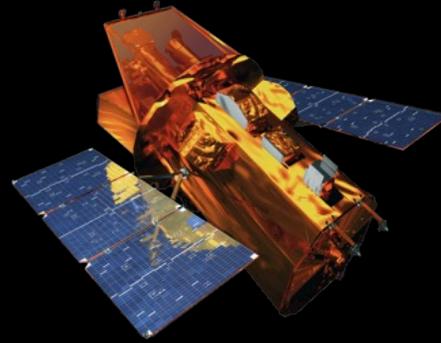
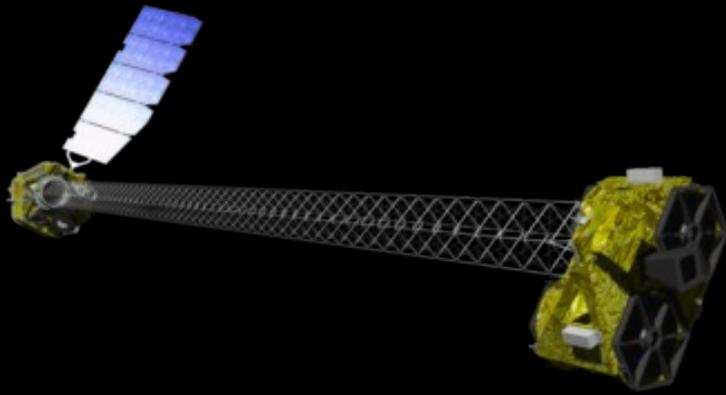
Get in Touch!

drop by my office C4.120

degenaar@uva.nl

nathaliedegenaar.com

Jakob van den Eijnden (Marie Curie research fellow)



Understanding stellar winds and accretion in HMXBs

Learn about:
Neutron stars and jets
Massive star winds
Binary dynamics

Learn to analyse data from
ATCA (radio)
INTEGRAL (X-ray)
Swift (X-ray)
NuSTAR (X-ray)
ALMA (mm)

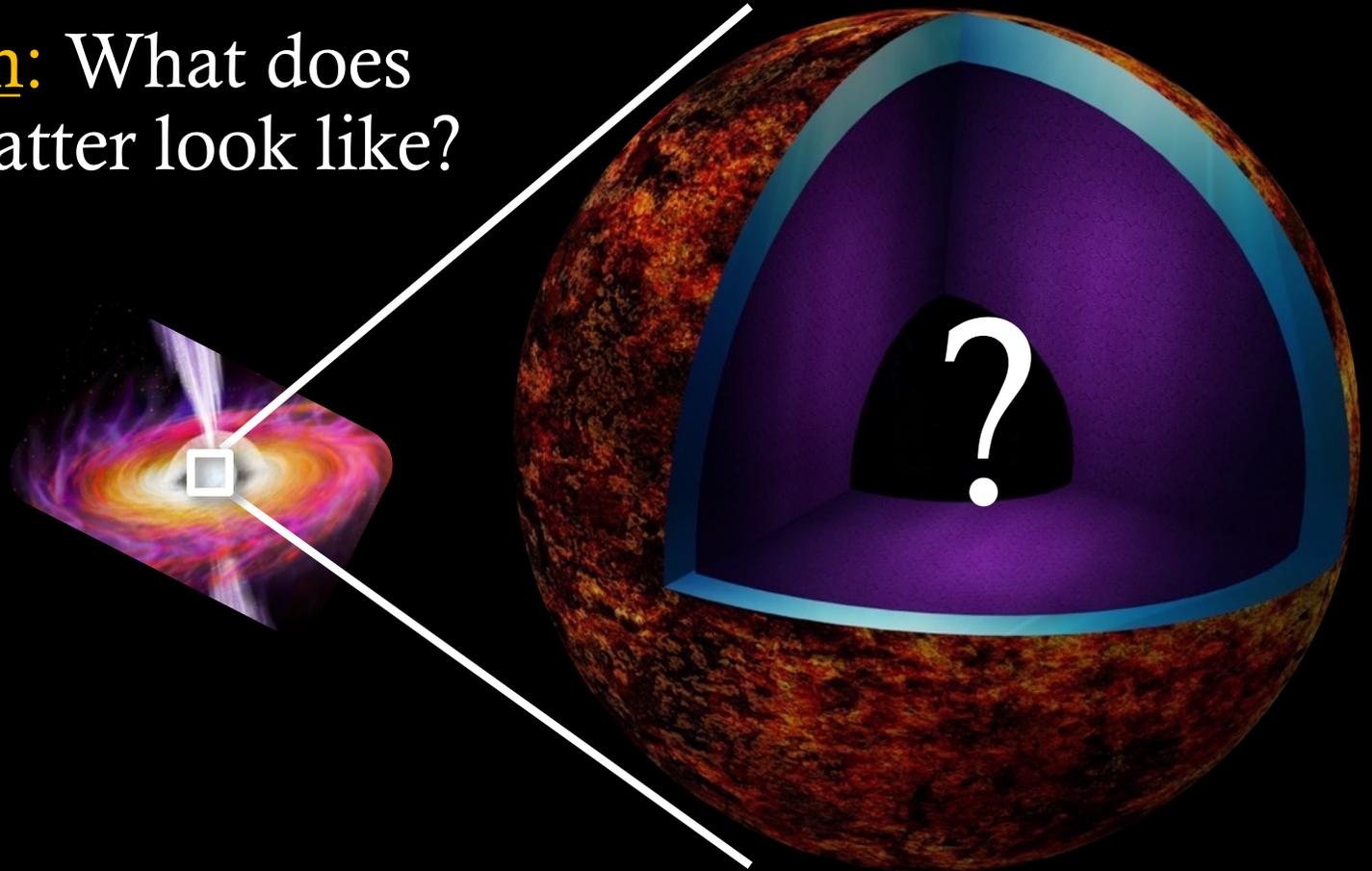


a.j.vandeneijnden@uva.nl

Deleted Scenes

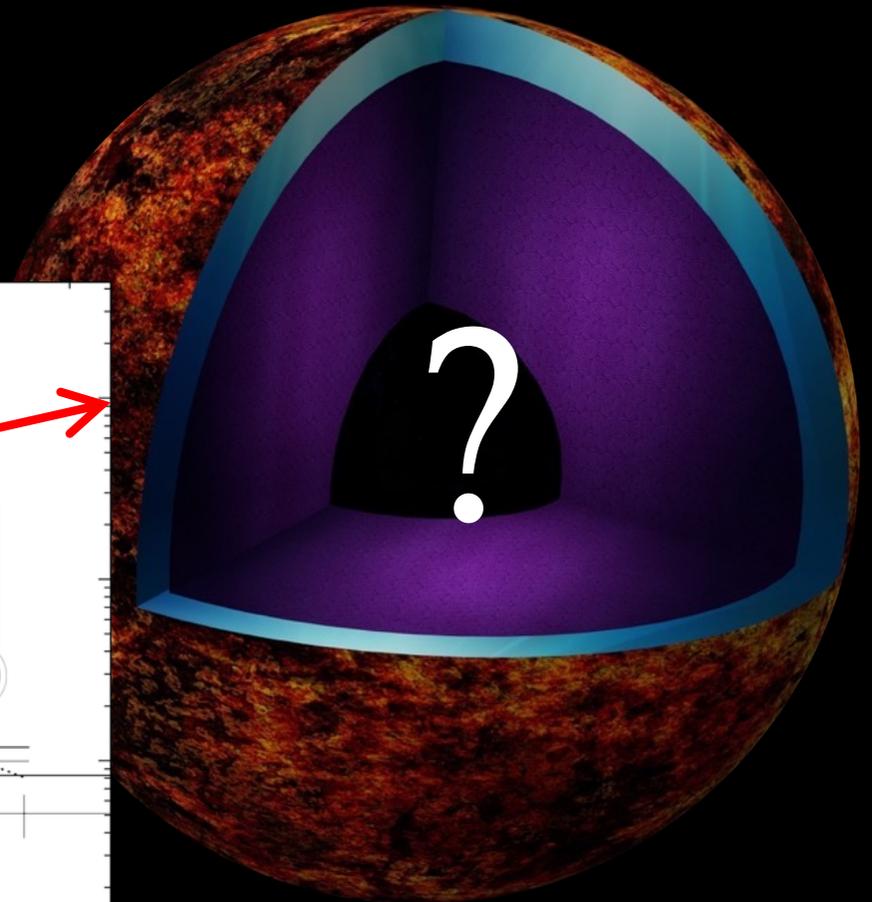
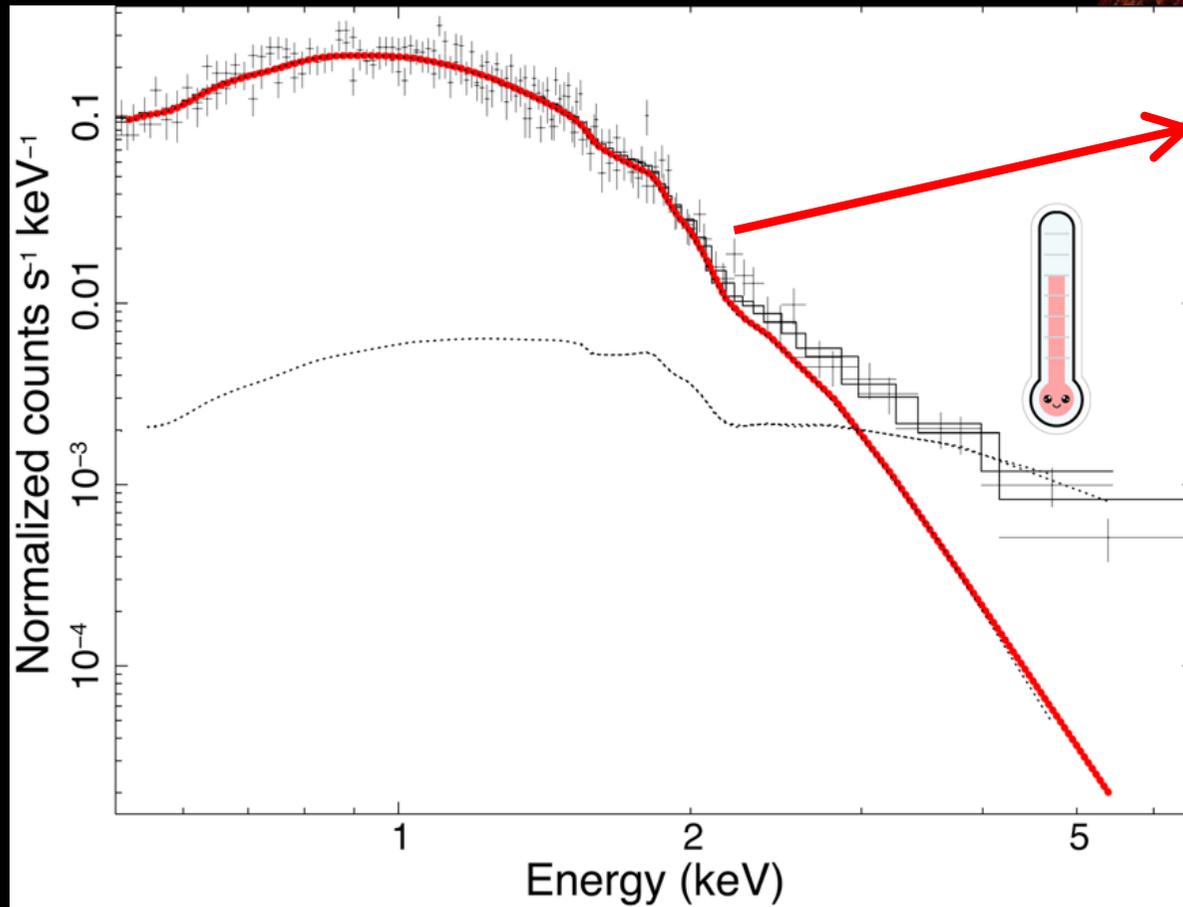
Project V: Inside a Neutron Star

Key question: What does ultra-dense matter look like?



Project V: Inside a Neutron Star

Key question: What does ultra-dense matter look like?

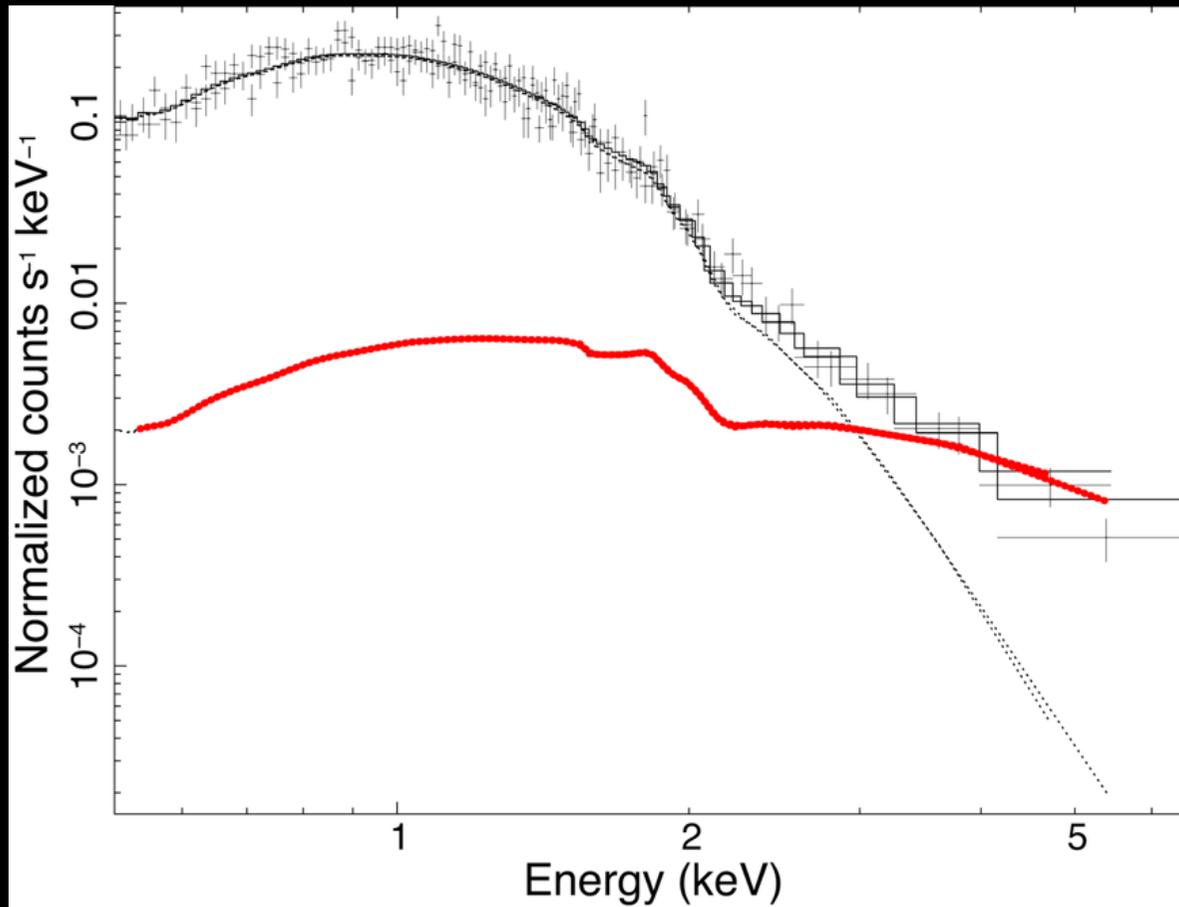


Thermal X-ray glow
→ probe of interior

Project V: Inside a Neutron Star

Data: Chandra and/or XMM-Newton

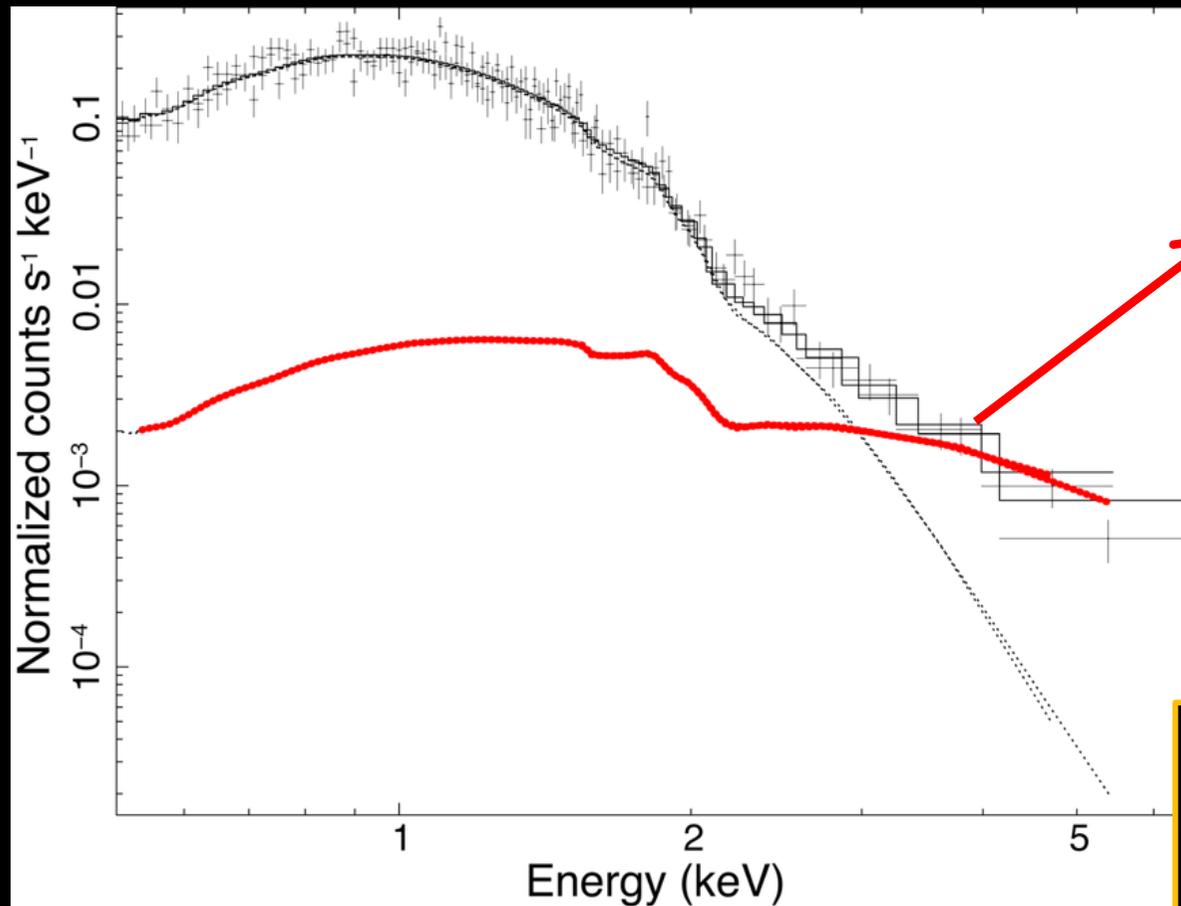
Analysis: X-ray spectra, NASA software



Targets:
~15 neutron stars

Project V: Inside a Neutron Star

Key question: What does ultra-dense matter look like?



Trouble in paradise:
additional emission
of unknown origin...
Weak accretion?
Magnetic activity?
Something else?

Crucial to understand
(‘contamination’)

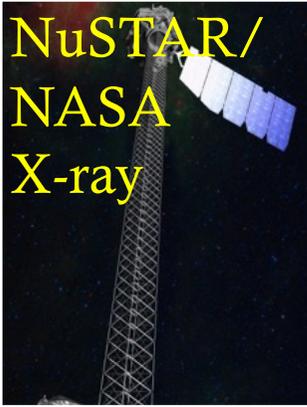
MSc Project Life

1. One-on-one with daily supervisor
Weekly + when needed (open door policy)
2. Group meeting (papers, talks, astro pictionary)
Weekly
3. Social meetings: lunches, celebrations, dinners
Few times per year

Ask (former) fellow students for their experience
(Ylvie, Qianhang, Daan, Simo)

How We Study X-Ray Binaries

NuSTAR/
NASA
X-ray



Chandra/NASA
X-ray



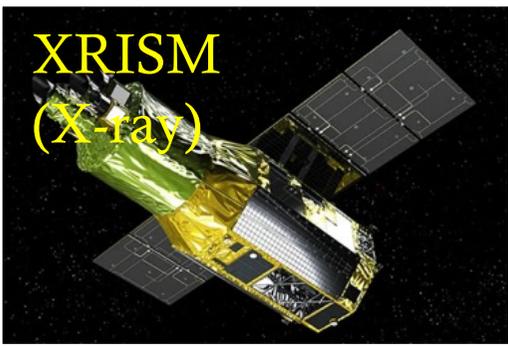
XMM-Newton/ESA
X-ray



Swift/NASA
X-ray + UV



XRISM
(X-ray)



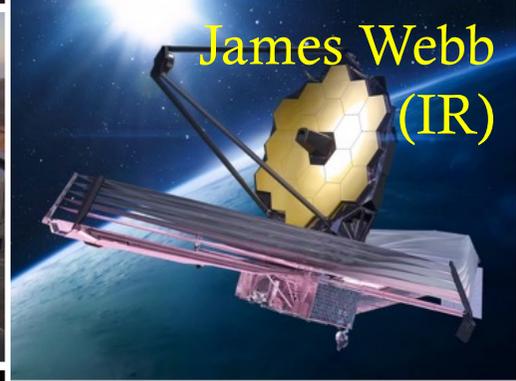
HST/NASA
UV



VLT (OIR)



James Webb
(IR)



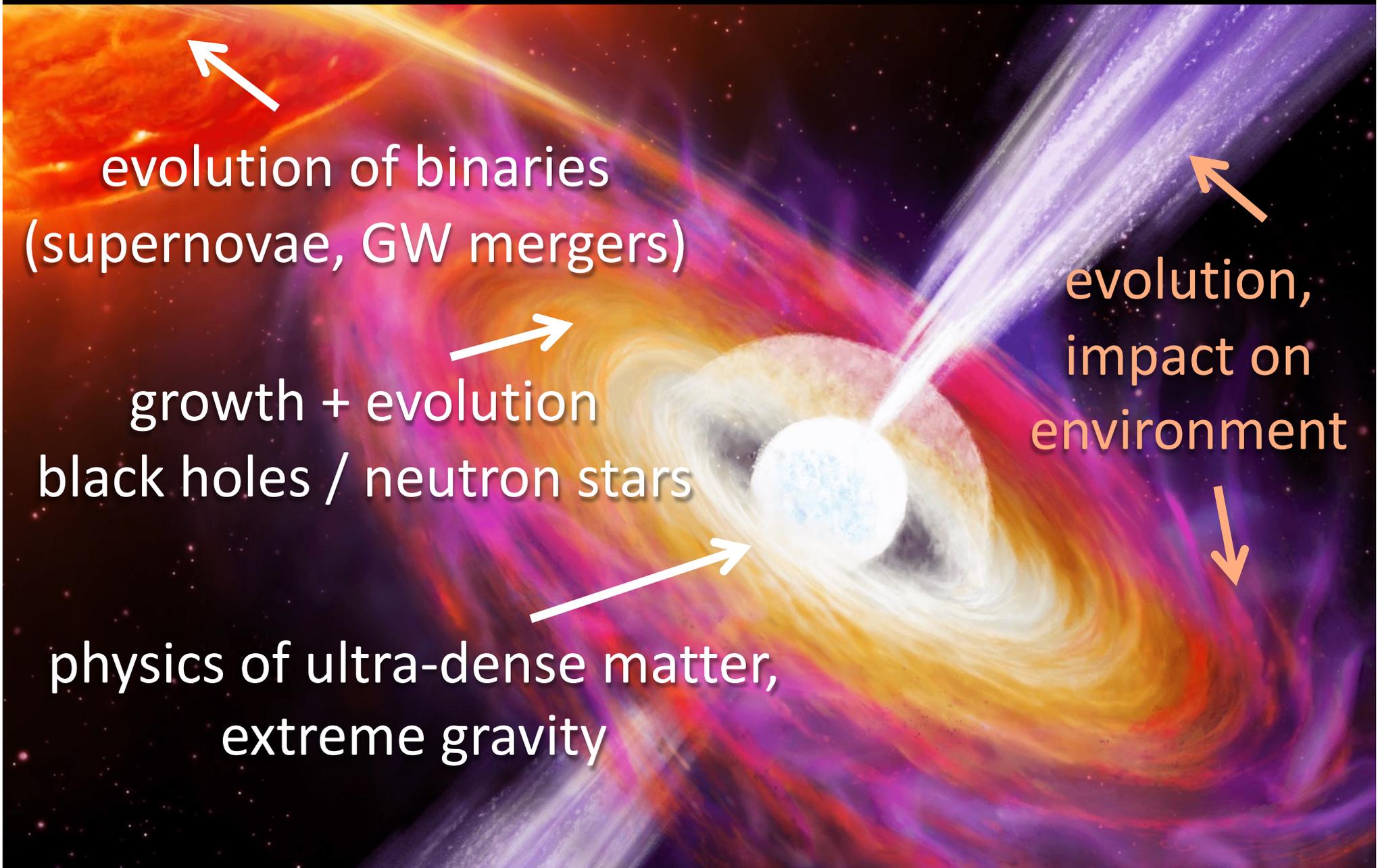
ATCA (radio)



VLA (radio)



Our X-Ray Binary Studies



evolution of binaries
(supernovae, GW mergers)

growth + evolution
black holes / neutron stars

physics of ultra-dense matter,
extreme gravity

evolution,
impact on
environment