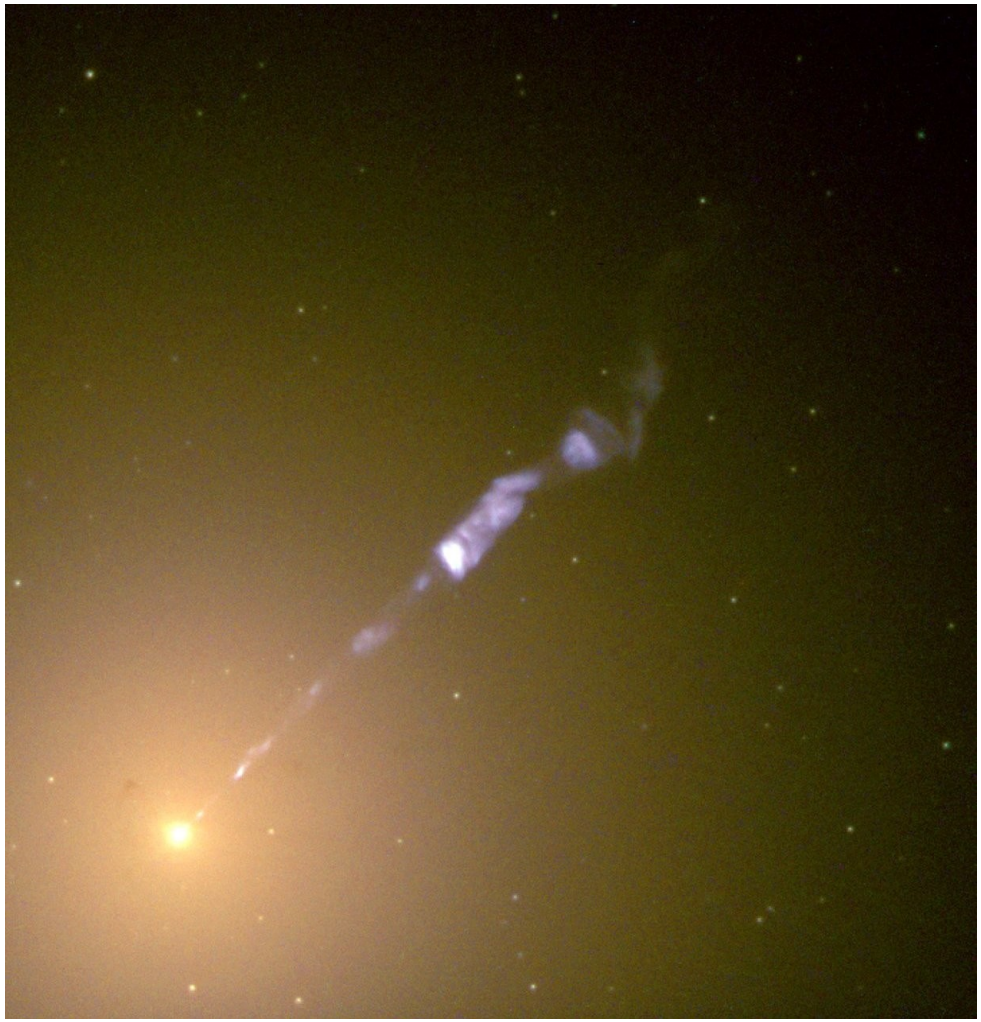
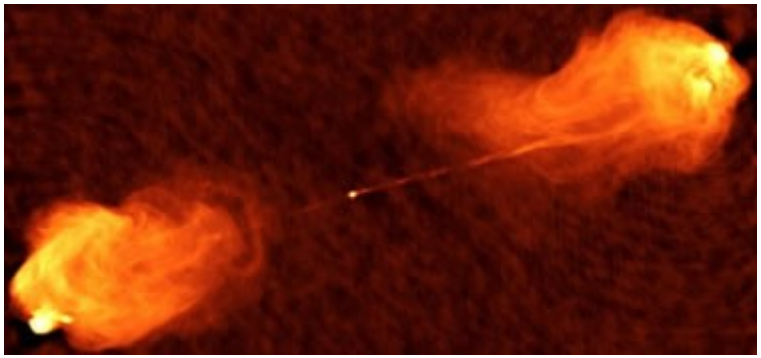
Theia+ and Astrophysical outflows



Anthony M. Brown
University of Durham, UK

anthony.brown@durham.ac.uk



Where, what, how and why.

In short: The ability to determine the position of astrophysical objects, or elements of them, with ~1μas precision, has important implications for our understanding of the physics of astrophysical outflows and the effect these outflows have on their surroundings.

What outflows are we talking about?

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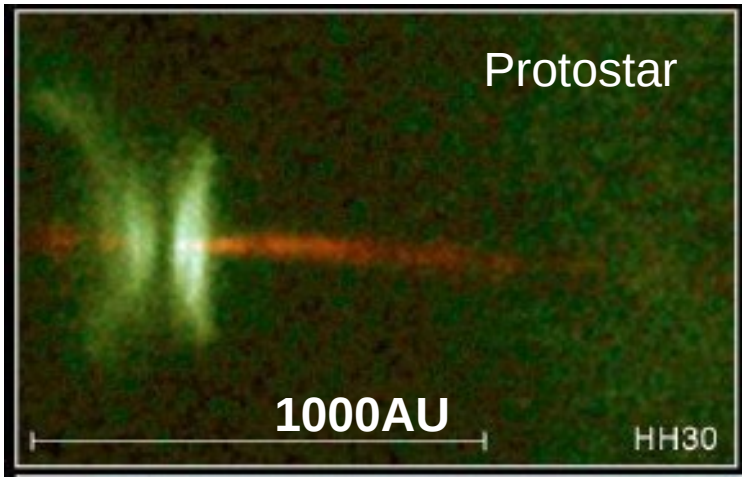
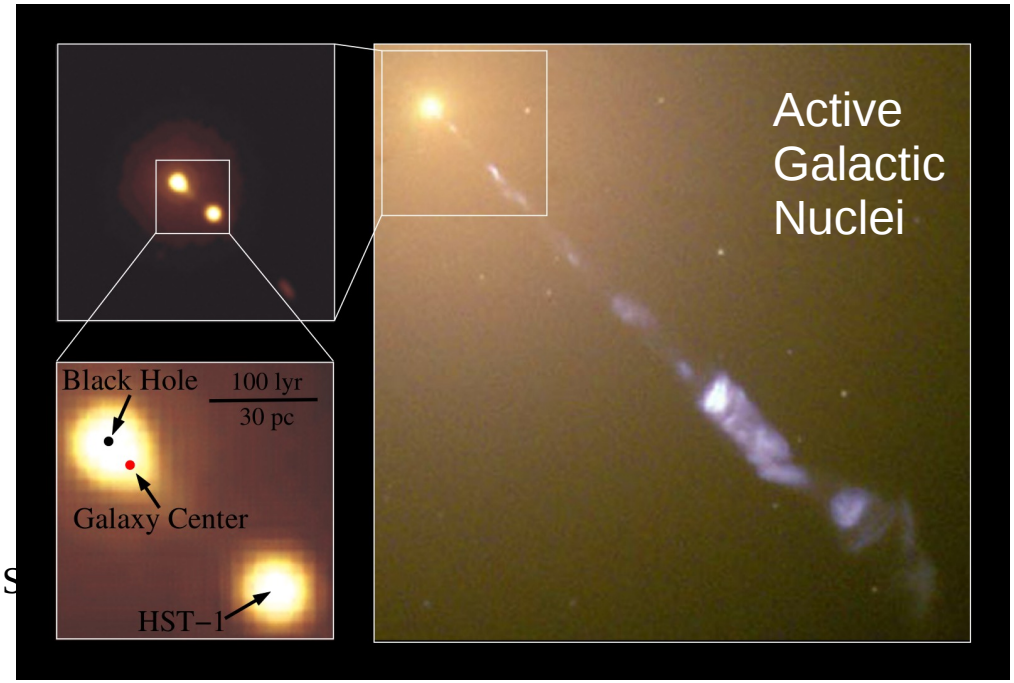
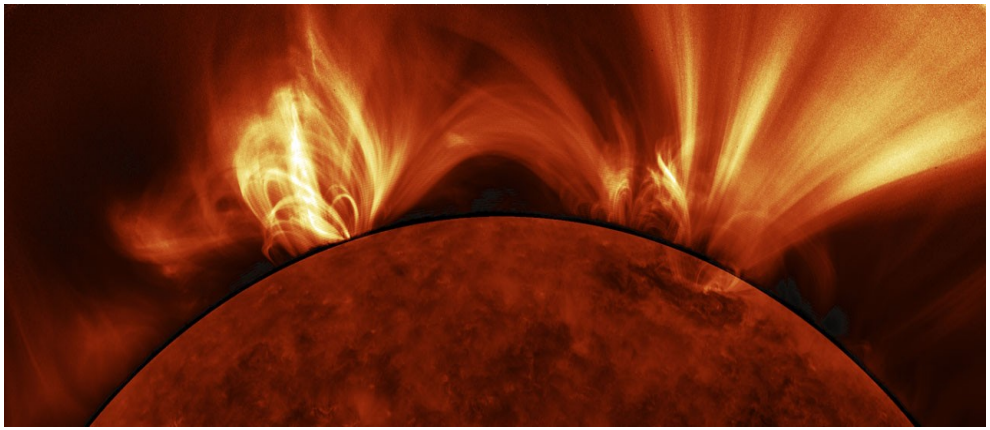
- Astrophysical jets:
  - broadly defined as collimated jets of material with a bulk motion away from an astrophysical 'engine'
  - a ubiquitous phenomenon in our Universe across a large range of length scales, from young stellar objects to Active Galaxies

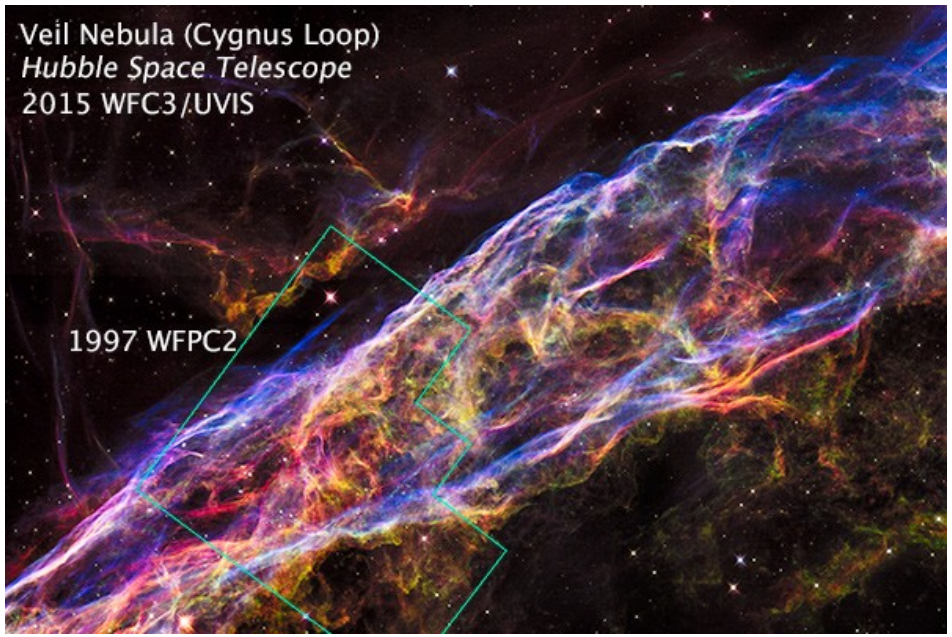


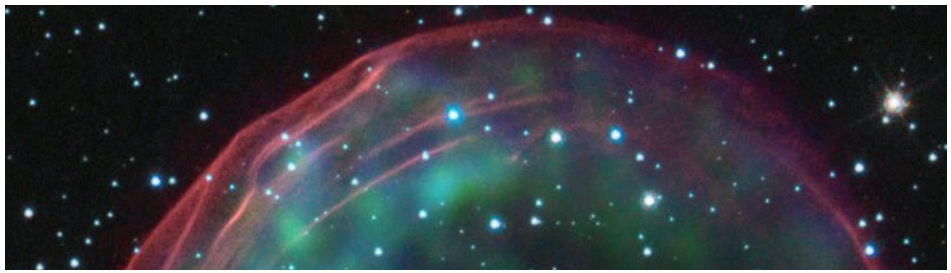


What outflows are we talking about?

- Stellar winds: strong winds from stars with velocities up to 1000 km/s (interesting for binary systems that emit gamma-rays).
- Shock fronts: wave of material/energy moving through an astrophysical environment (often the acceleration sites of high energy particles).



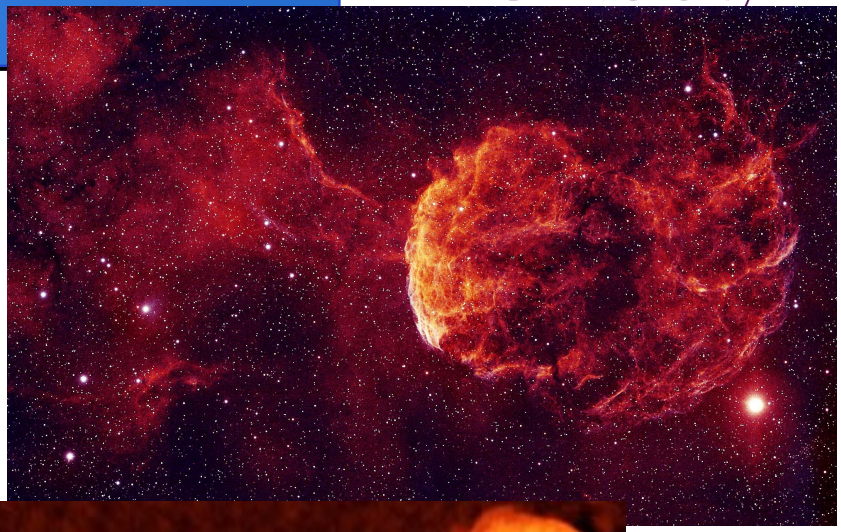


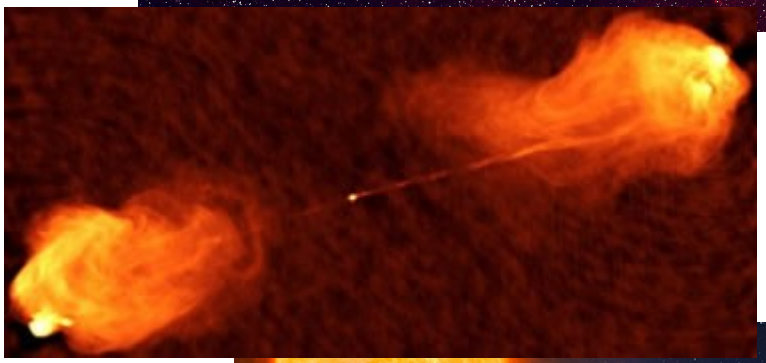


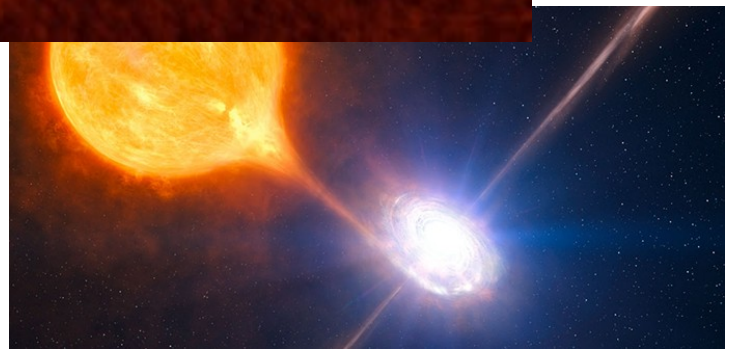
Where can we find these outflows?

- Active Galactic Nuclei
- Galactic binaries
- Novae
- Pulsar wind nebula
- Supernovae remnants
- Young stellar objects
- Star forming regions
- .....

  Alot of places...!!!!







Why would Theia care? (Or, how can Theia help?)

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- Case study (i) Active Galactic Nuclei

  1000s of AGN, who possess relativistic jets, have been found to be gamma-ray bright. Rapid flare events of some of these AGN have brought our current understanding of the origin of the gamma-ray emission into question: this is often referred to as the 'Doppler crisis' (eg. Aharonian et al. 2007, ApJ, 664, 71 & Albert et al. 2007, ApJ, 669, 862)

- Several models have since arisen to address this doppler crisis, suggesting velocity structure within AGN jets.

  →μas astrometry allows us to map the velocity structure and directly address the role that it plays in the emission of AGN gamma-rays

Why would Theia care? (Or, how can Theia help?)

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- Case study (i) Active Galactic Nuclei

  NGC1275 is a prominent radio galaxy at a redshift of z=0.017

  - @ this distance, 1μas ≈ 3×10^{-3} pc
  - Brown & Adams, 2011 found NGC 1275's gamma-ray emission to vary on timescales as short as days, implying a compact emission region on the scale of 2×10^{-3} pc

  M87 is a prominent radio galaxy at a redshift of z=0.004

  - @ this distance 1μas ≈ 10^{-3} pc
  - Aharonian et al., 2006 found M87's gamma-ray varying flux to imply a compact gamma-ray emission region on the scale of 10^{-3} pc (consistent with other findings of AGN variability eg, Brown, 2013)

  → the μas astrometry of Theia+ would allow us to directly observe the emission region associated with a gamma-ray flare for near-by radio galaxies

Why would Theia care? (Or, how can Theia help?)

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- Case study (ii) Novae

  accreting binary systems that have a runaway thermonuclear explosion on the surface. Some found to be gamma-ray bright (up to distances of 5 kpc from us).

  - Velocity of mass ejection during explosion found to be an important parameter in our model fit to the gamma-ray flux observed (eg. *Fermi* collaboration, 2014, Science)
  - Theia can help us constrain the actual velocity of the outflow and thus determine if other parameters, such as binary separation (which Theia can also constrain) or wind density are the primary parameter which governs whether gamma-ray emission is observed.

Why would Theia care? (Or, how can Theia help?)

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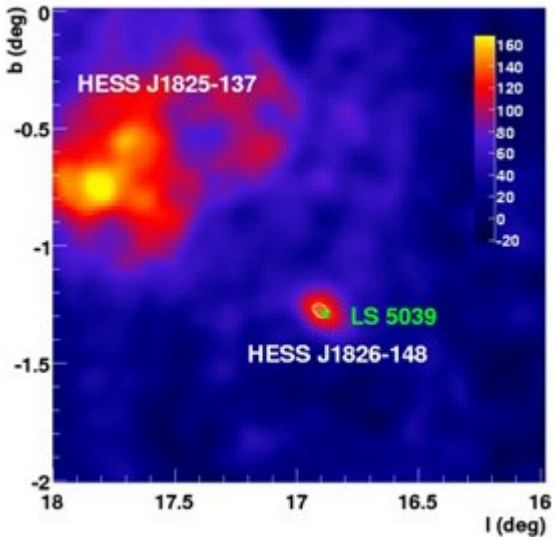
- Case study (iii) Galactic binary systems
  - Some galactic binaries have been found to be gamma-ray bright, with outflows (whether it be strong wind or mildly-relativistic jets)
  - Eg LS 5039 is a gamma-ray bright binary at a distance of 3kpc, with a mas long jet.

    μas astrometry would allow us to probe structure within the jet,

    as well as resolve the

    two components of

    binary system



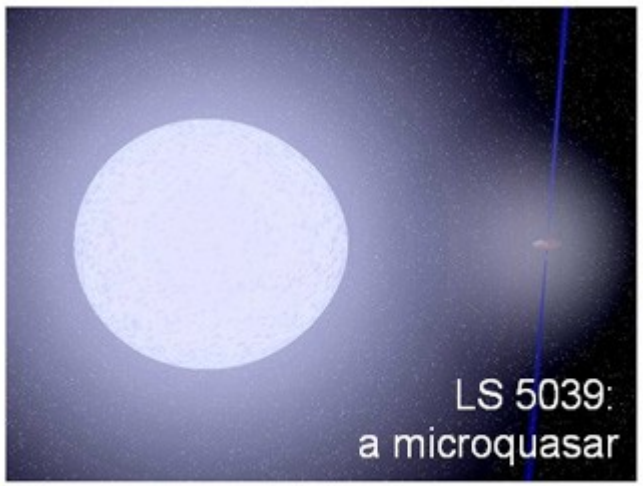


Image generated using software by Rob Hynes (LSU)

How Theia will observe?

- Essentially, studying outflows with Theia will be a mix of planned observations and ToO (target of opportunity) observations when a flare event occurs.

- Any questions: please don't hesitate to get in contact

  anthony.brown@durham.ac.uk