Are galactic collisions responsible for the triggering of active galactic nuclei?

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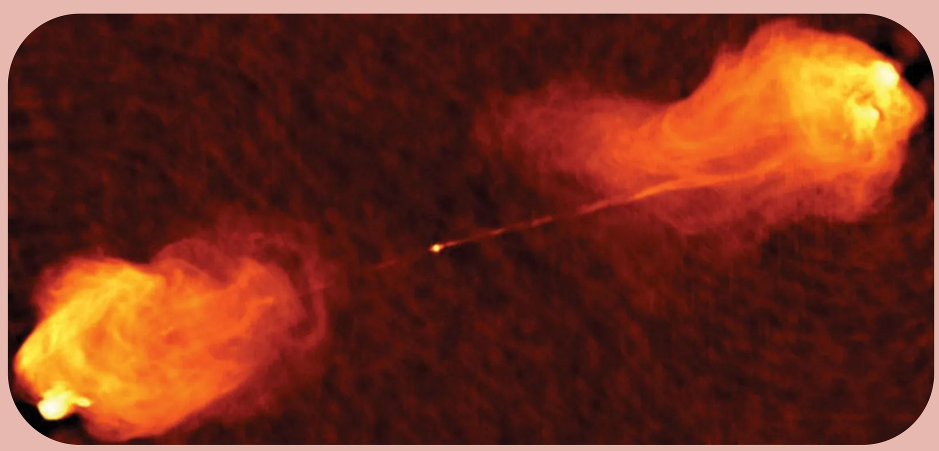
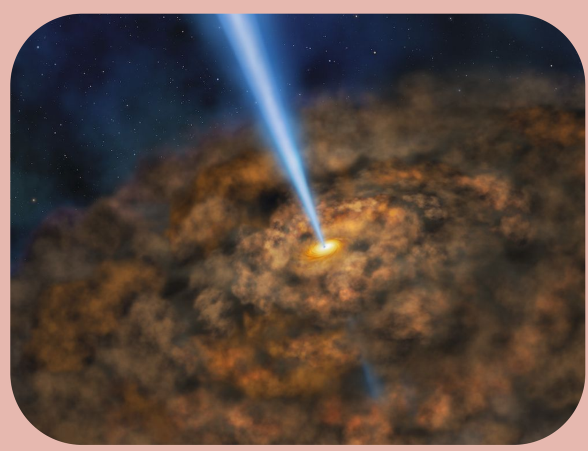
What are active galaxies?

- **Active galaxies** are some of the most powerful objects in the Universe, first studied 80 years ago
- These galaxies contain **active galactic nuclei** (AGN), powered by the accretion of gas into a black hole





An FRII ("edge-brightened") source (left), and an artist's impression of an AGN (right)
Credits: Encyclopædia Britannica and Lynette Cook/NASA/SOFIA

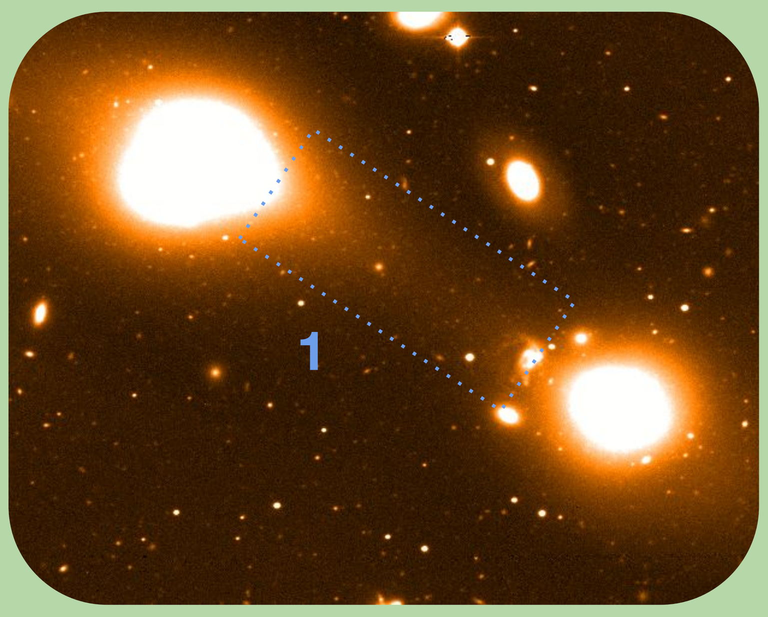
- AGN consist of **various subtypes**, including **radio-loud AGN**, which show powerful jets of relativistic particles
- Most subtype differences can be explained by viewing angle
- However, amongst the radio-loud AGN, some differences cannot be explained in this way:
  - Low- vs high-excitation (LEGs and HEGs)
  - Different structures at radio wavelengths (FRIs and FRIIs)

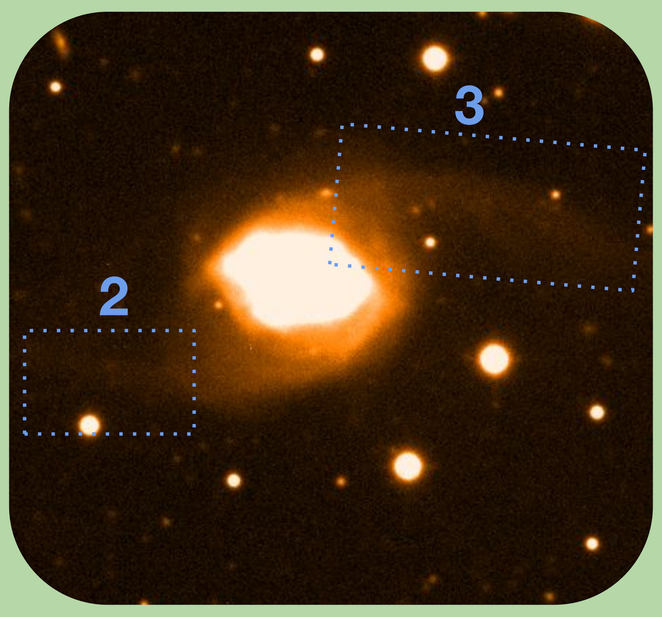
Why study AGN?

- As AGN are so powerful, they have a **crucial effect on galaxy formation and evolution**
- Understanding the way in which they are triggered will help to refine models of this evolutionary period
- Investigating triggering methods may also help to explain differences between LEGs/HEGs and FRI/FRII galaxies
- **The way in which AGN are triggered is still debated amongst astrophysicists**, with some preferring instances of galactic mergers while others theorise some form of hot gas accreting into the black hole
- In this project, the method of galactic mergers was tested

Identifying triggering methods

- Tidal features in the active galaxy are **good indicators of prior galactic interactions or mergers**
- If an active galaxy shows tidal features, its AGN is assumed to have been triggered via mergers or interactions
- There are numerous distinct tidal features, but generally the galaxy is obviously visually disturbed
- Tidal features are classified as either **"pre-" or "post-coalescence"**, indicating whether or not the AGN was triggered before or after the galaxies fully merged





Examples of galaxies with tidal features. 3C40 (left) contains a "bridge" (labelled 1) connecting it to a nearby source, while 3C305 (right) shows distinct "tails" (labelled 2 and 3) protruding from the nucleus.

Take images

Images were taken of 30 AGN in the 3CR sample (Buttiglione et al., 2009). The images were the deepest yet taken of these sources, to better identify fainter tidal features.

Find tidal features

Using Starlink's GAIA software, the images were analysed for the presence of tidal features. GAIA allowed for the manipulation of the image's colour, depth, contrast and brightness.

Classify AGN

The AGN were classified according to their individual tidal features. The classification system of Pierce et al., 2021 was used.

Find disturbance rates

Disturbance rates were calculated for each AGN subtype and combined with 72 other sources from Pierce et al. (2023), creating a sample of 102 galaxies.

Results

48%
of the 102 sample galaxies showed tidal features and disturbances.

66% vs 37%
HEGs were far more likely to be disturbed than LEGs.

~40%
of disturbed galaxies had notably faint tidal features that may have been missed by previous studies.

89% vs 38%
AGN in FRI galaxies were far more likely to be triggered before the merger than AGN in FRIIs.

Conclusions

- Different AGN subtypes were found to have different triggering mechanisms **at high significance for the first time**
- Interactions and mergers **play a large part** in triggering the most powerful AGN
- In the future, control galaxies should be introduced to produce more robust results and minimise observational bias

References

Buttiglione S., Capetti A., Celotti A. et al. (2009). A&A 495 (3), p. 1033–1060
Pierce J., Tadhunter C., Gordon Y. et al. (2021). MNRAS 510 (1), p. 1163–1183
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Acknowledgments and credits

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