Question 1:

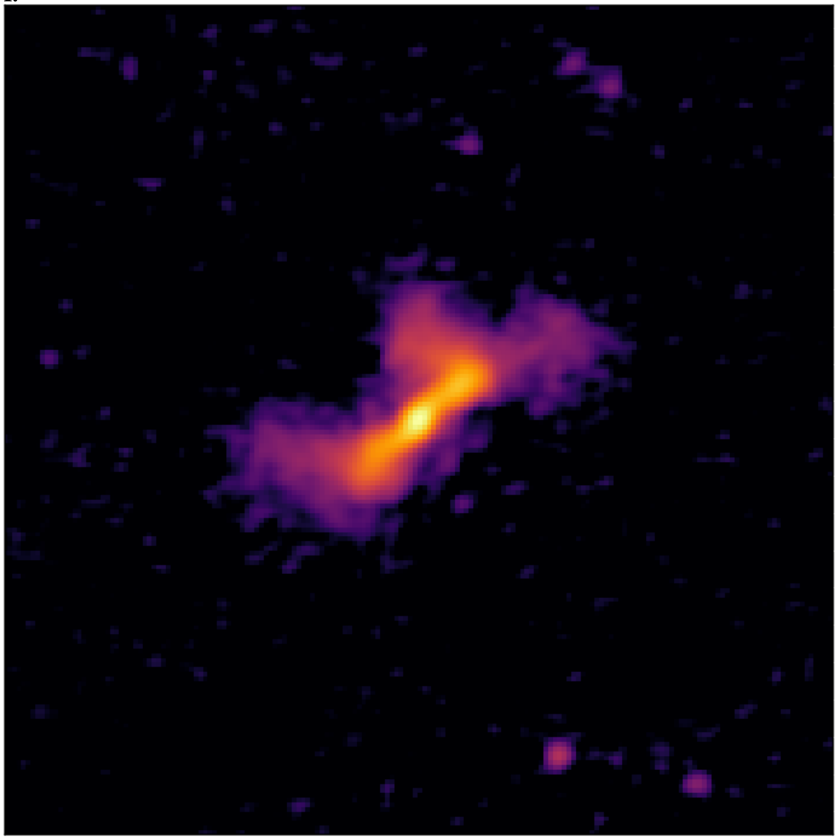
a)
i.


Figure 1: Example of Fanaroff-Riley type I radio source
Bright jets in the centre and fading outwards.

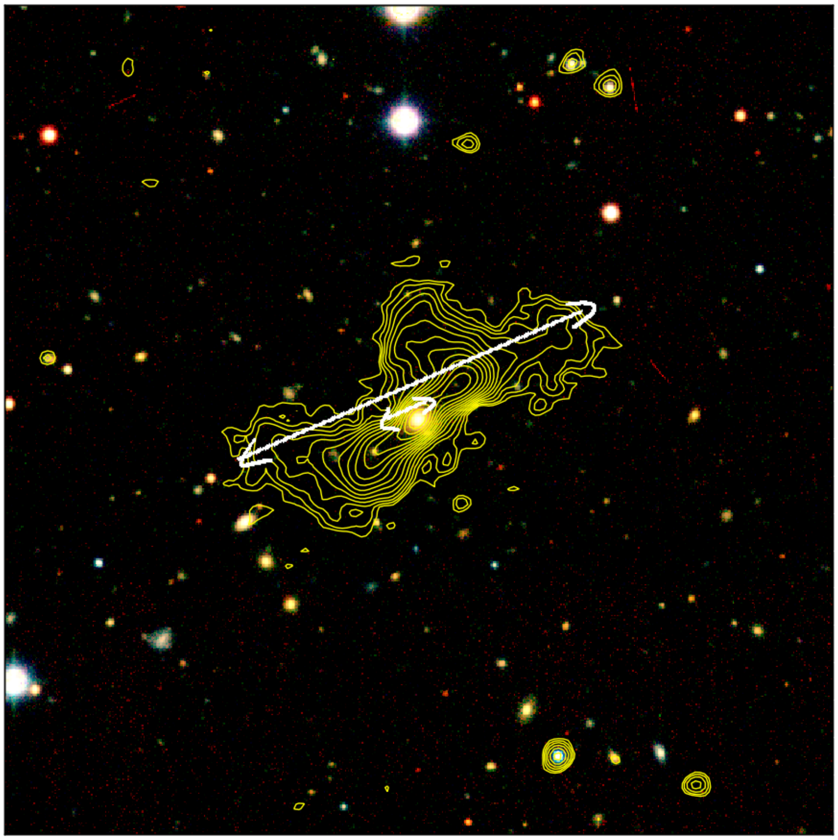


Figure 2: Example of Fanaroff-Riley type I optical source with overlaid radio contours
Big elipse with no real extension.

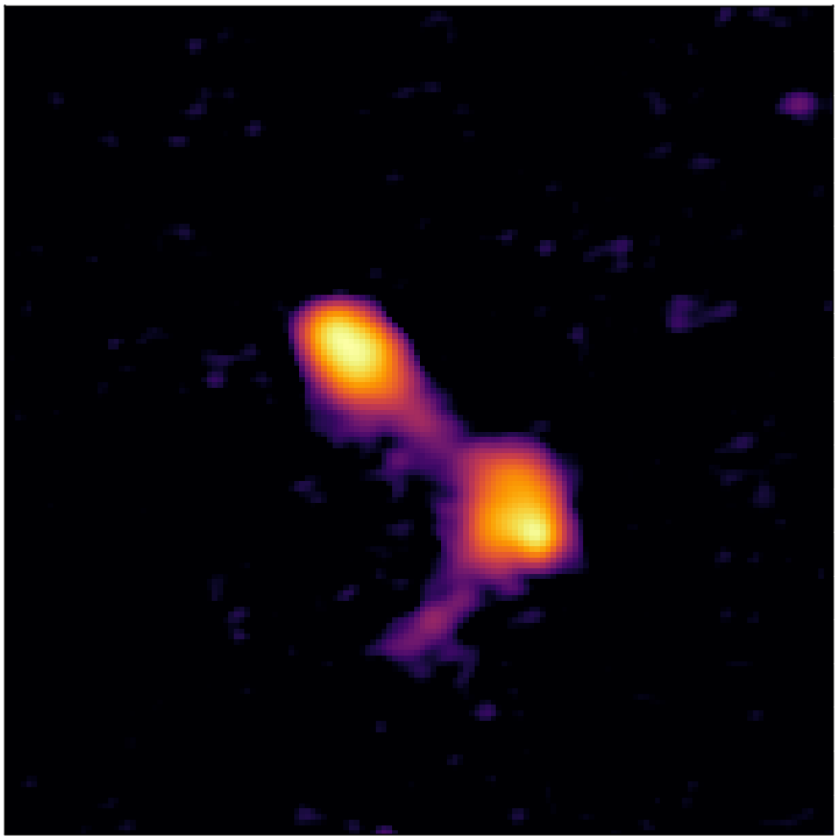


Figure 3: Example of Fanaroff-Riley type II radio source
Bright lobes with a weak core.

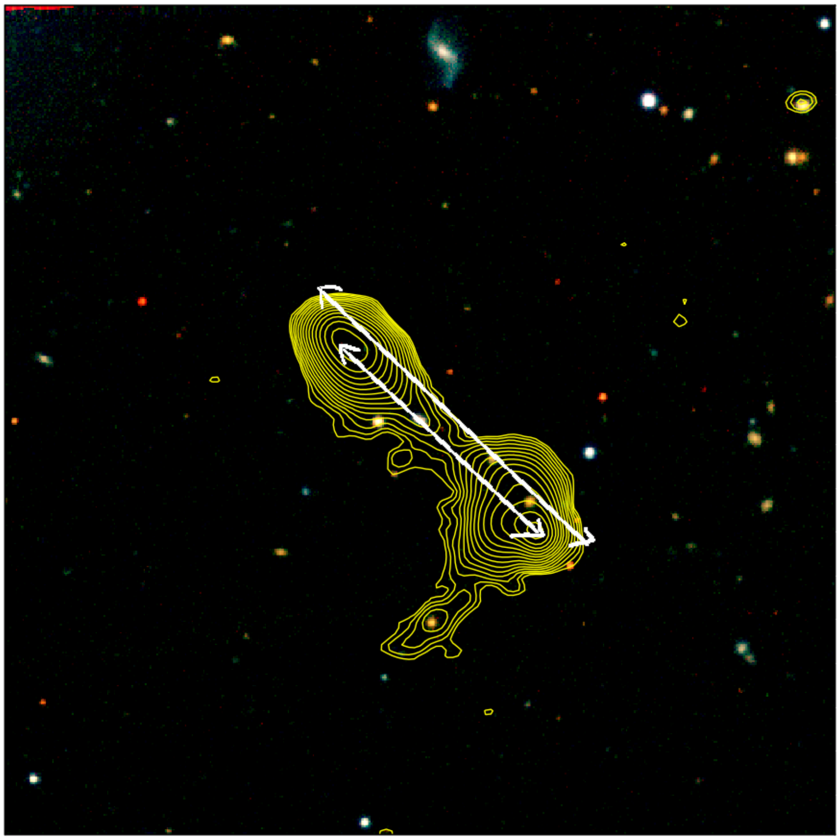


Figure 4: Example of Fanaroff-Riley type II optical source
Distict bright lobes with narrow line radio emissions.

1

Good

ii.

In an FR I the peak surface-brightness occurs within the inner half of the source, giving an FR ratio < 0.5, whereas in an FR II the hot-spots are at the extremities so the ratio > 0.5. Visual inspection of Figs 1 3 shows the bright knots are (respectively) near the core and at the lobe edges, so Fig 1 must have FR ratio < 0.5 (type I) and Fig 3 > 0.5 (type II).

Correct, though for pick up the marks here you needed to indicate the lengths you have measured on your images and also give numerical calculations to support your classifications.

2/4

b)

i.

$$L = \frac{GM\dot{M}}{R}$$

$$L_{Edd} = \frac{4\pi G M m_p c}{\sigma_T}$$

You should retain the inequality here as $L \leq L_{EDD}$ in the question.

hence

$\leq$

$$\frac{GM\dot{M}}{R} = \frac{4\pi G M m_p c}{\sigma_T}$$

$$\frac{GM\dot{M}}{4\pi G M m_p c} = \frac{R}{\sigma_T}$$

$$\frac{\dot{M}}{4\pi m_p c} = \frac{R}{\sigma_T}$$

$$\dot{M}_{\text{Edd}} = \left(\frac{4\pi m_p c}{\sigma_T}\right) R$$

1

As π, m_p, c, σ_T are all constants this shows that maximum accretion rate depends only on the radius of the accreting object

Good, well - explained.

And as

$$R = \frac{2GM}{c^2}$$

$$\frac{2GM}{c^2} \implies \dot{M}_{\text{Edd}} = \left(\frac{8\pi G m_p}{\sigma_T c}\right) M$$

1

and thus the the maximum accretion rate of a black hole depends only on its mass

ii.

This needs to be given in kg to result in your answer in kgs-1

$$\dot{M}_{\text{Edd}} = \left(\frac{8\pi G m_p}{\sigma_T c}\right) M$$

$$= \frac{8\pi\,(6.67\times10^{-11}\,\mathrm{N\cdot m^2/kg^2})(1.67\times10^{-27}\,\mathrm{kg})(1\times10^{9}\,\mathrm{M_\odot})}{(6.652\times10^{-29}\,\mathrm{m^2})(3.00\times10^{8}\,\mathrm{m\,s^{-1}})}$$

$$\approx 2.8\times10^{23}\,\mathrm{kg\,s^{-1}}$$

2

Divide by seconds in a year, and multiply by solar mass to give

$$\approx 4.4\,\mathrm{M_\odot}/\mathit{yr}$$

4/4

Total for question 1: 6/8

First, introduce yourself and your organisation.

Question 2:

Slide 1: In May 2023, the LIGO-Virgo-KAGRA collaboration detected a gravitational-wave signal, GW230529, during the early part of its fourth observing run. The event was picked up by the LIGO Livingston detector while the other observatories were offline or not sensitive enough. This signal came from a binary merger involving a compact object with a mass between 2.5 and 4.5 times that of our Sun, and a neutron star between 1.2 and 2.0 solar masses. What makes GW230529 especially intriguing is that the more massive object sits in the so-called 'lower mass gap'—a previously underpopulated range between the heaviest known neutron stars and the lightest known black holes. This detection adds compelling new evidence to the growing case that nature might be more adventurous in populating this gap than previously believed.

Good.

Good, informative image on your slide, but make image larger - text too small for audience to read.

Slide 2: GW230529 was detected on 29 May 2023 at 18:15 UTC by the LIGO Livingston detector. It was a strong signal, standing out from background noise and independently confirmed by three search pipelines using matched-filtering techniques. These pipelines compare real-time data to theoretical templates, and in this case, all three flagged GW230529 as highly significant. The signal's strength was such that even though only one detector was operational, the false alarm rate was estimated at less than one in a thousand years—making it an extraordinarily reliable detection. The waveform of the signal suggests a merger between two compact objects: one significantly heavier than the other, with the heavier component likely lying in the mass gap region between neutron stars and black holes. This event marks one of the most asymmetric mass ratios observed in neutron star–black hole mergers.

Good, though explain how the image on your slide relates to this.

Slide 3: he binary system responsible for GW230529 had a primary object with an estimated mass between 2.5 and 4.5 solar masses, and a secondary object between 1.2 and 2.0 solar masses. This puts the heavier component squarely in the "lower mass gap," a region previously thought to be empty. The total mass of the system was around 5.1 solar masses, with a chirp mass, the effective mass of a binary system (black holes or neutron stars able to produce detectable gravitational waves), in the context of the Quadrupole Gravitational Radiation emitted by it.—one of the most precisely measurable properties of a gravitational-wave event—of about 1.94 solar masses. The spin of the primary was measured to be moderate, and the system as a whole showed no signs of precession. Although we can't be 100% sure of the nature of the heavier object, statistical analysis suggests it's more likely to be a low-mass black hole rather than a massive neutron star. Meanwhile, the lighter companion is almost certainly a neutron star, based on its mass and lack of strong spin evidence. The system was located roughly 200 million light-years away, based on its redshift.

OK but your slide doesn't add to this - add image?

Slide 4: Because GW230529 was only detected by a single observatory—LIGO Livingston—localising its position in the sky was challenging. Without input from the other detectors, the sky area where the signal could have originated remained broad. This poor localisation made it difficult for telescopes to follow up with electromagnetic observations. Despite this, several observatories attempted follow-up campaigns, including searches for gamma-ray bursts, neutrinos, and optical transients. No significant electromagnetic counterpart was identified. However, models suggest that tidal disruption of the neutron star—and thus visible emissions—is only likely under specific conditions, such as a high spin and favourable mass ratio. For GW230529, those conditions weren't definitively met, and the amount of matter expected to be left outside the black hole post-merger was likely too small to power a bright visible signal.

Good - maybe add graphic to show position on the celestial sphere?

Slide 5: GW230529 is a landmark detection for several reasons. First, it adds weight to the growing evidence that the so-called 'lower mass gap'—the region between the heaviest neutron stars and the lightest black holes—is not as empty as once thought. Previously, neutron stars were found through radio or X-ray emissions, typically under 2.5 solar masses, and black holes were seen in X-ray binaries, mostly above 5. This left a gap that may have simply reflected observational bias. Gravitational-wave detections, like GW230529, don't rely on light and can reveal compact objects solely through their mass and motion. The discovery of a likely black hole with a mass in the 3–5 solar mass range challenges previous assumptions and could reshape our understanding of stellar collapse and compact object formation. It also nudges models of supernova physics and binary evolution toward accounting for lower-mass black holes and more diverse merger pathways.

✓ **Good science here! Though again your slide isn't really adding anything extra to this.**

Collaboration scientists say roughly 80 more strong candidates are already under study, and they expect the tally of gravitational-wave detections to top 200 by the end of O4.

1) Scientific content of slides and script: Score 6/8
Lots of good scientific information in this presentation, well done, but I would have liked to see more information on your slides in the form of images - only two of your slides included images containing data.
However, you stress the importance of this event due to one of the two progenitor objects being in the lower mass gap and give an explanation for this - well done.
You also highlight the difficulties presented by a single observation - also good.

2) Appearance of text and images on slides: Score 5/8
Good use of images and font sizes, uncluttered layout.
You chose some good images and made good use of text to summarise your script, but I thought you could have included more visual representations of data on your slides.
Take care to follow instructions carefully in questions - you were directed to use no more than 5 slides for your presentation.

3) Clarity, conciseness and coherence of script: Score 6/8
Your script was engaging, interesting and coherent, and was well-ordered with a logical flow from start to finish - well done!

Total for question 2: 17/24

Grand Total: 23/32