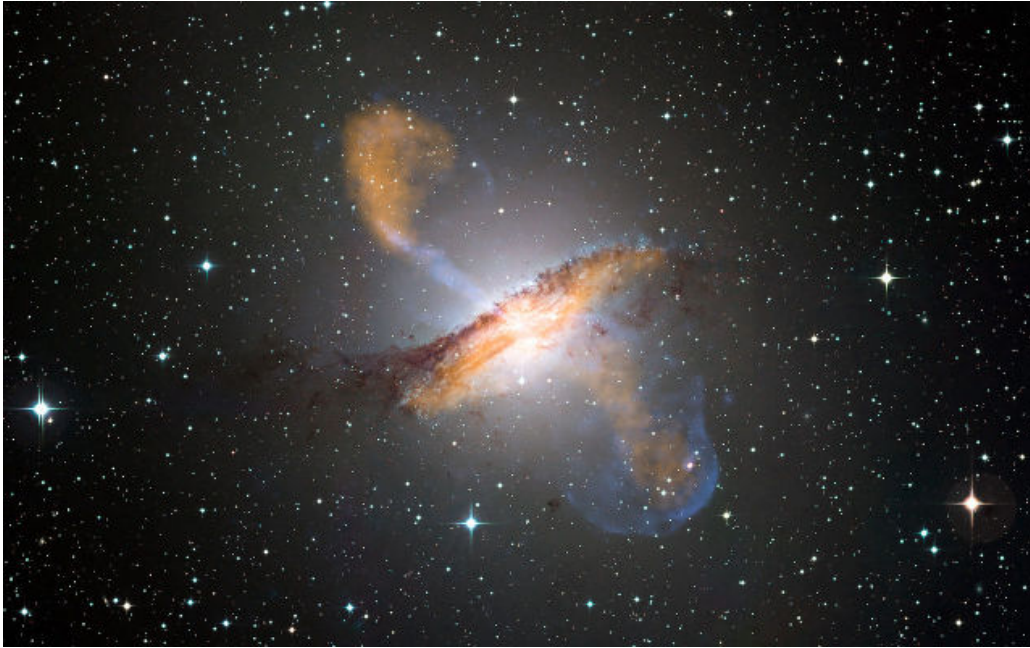


CRLS Astrophysics Lecture Series

In Search of Erupting Black Holes

Sandro Tacchella



Color composite image of Centaurus A, revealing the lobes and jets emanating from the active galaxy's central black hole.

Week 1: Introduction to galaxies and black holes

Goals

Next week we will look for erupting black hole in galaxies using real observational data. To get ready, this week we will learn first about galaxies and black holes, and their basic properties. Then, we will learn about the physics of light and the electromagnetic spectrum and, finally, see how to look for black holes.

Outline

The following sections outline some questions to guide your exploration of the listed resources. Take note of any additional questions that come up, and we will discuss them next week.

1. Galaxies

Guiding questions:

What is a galaxy? What are the main constituents of a galaxy? What kinds of galaxies are there?

Resources:

<http://planetary-science.org/astrophysics/galaxies-4/an-introduction-to-galaxies/>
<https://en.wikipedia.org/wiki/Galaxy>

2. Black Holes

Guiding questions:

What is a black halo? From where do we know that black holes exist? How massive are black holes? Where can we find black holes?

Resources:

General articles about black holes: <https://science.nasa.gov/astrophysics/focus-areas/black-holes> and https://en.wikipedia.org/wiki/Black_hole

Also follow the link to supermassive black holes:

https://en.wikipedia.org/wiki/Supermassive_black_hole

3. Light

Guiding questions: What is the electromagnetic spectrum? Which part of the spectrum can we see with our eyes? With what kind of telescopes can detect which part of the spectrum?

Resources:

<https://imagine.gsfc.nasa.gov/science/toolbox/emspectrum1.html>

https://imagine.gsfc.nasa.gov/science/toolbox/emspectrum_observatories1.html

https://en.wikipedia.org/wiki/Electromagnetic_spectrum

4. Finding erupting black holes

Guiding questions:

How can we find black holes? At which part of the spectrum should we look for them? With which telescopes?

Resources:

http://hubblesite.org/explore_astronomy/black_holes/encyc_mod1_observatories.html

<https://www.space.com/3457-tricky-task-detecting-black-holes.html>

Read more about the image above: <http://www.constellation-guide.com/centaurus-a/>

Summary questions

After reading and discussing the aforementioned articles, you should be able to answer the following questions. Don't worry if different people have different answers – there's more than one way to answer these questions. What's important is that you feel comfortable answering them and debating your answers.

1. Where can we find the biggest black holes in the Universe?
2. At which wavelengths do galaxies emit light?
3. How can we find black holes in other galaxies?

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Week 2: Radio Galaxy Zoo and supermassive black holes

Goals

Last week we learned about galaxies and black holes, and how we can find them. This week we will look for erupting black hole in galaxies using real observational data. In particular, we will use “Radio Galaxy Zoo” (<https://radio.galaxyzoo.org/>), which is a citizen science project designed to hunt for supermassive black holes and consists of radio observations from the Jansky Very Large Array (JVLA) and the Australia Telescope Compact Array (ATCA).

Outline

The activity this week will be very hands-on, and open-ended, so below is just a suggested outline. As always, ask any questions that come up!

1. Recap from last week

What are galaxies and black holes? At which wavelengths do we need to look for them?
What kind of telescopes should we use?

2. Short introduction to Galaxy Zoo Radio

Radio Galaxy Zoo is a new citizen science project that lets anyone become a cosmic explorer. It does that by matching galaxy images with radio images; a participant can work out if a galaxy has a supermassive black hole. We will discuss why do astronomers need your help and what do astronomers hope to learn?

3. Look for black holes

- Set up you account at <https://radio.galaxyzoo.org/>
- Work yourself through the tutorial when you start classifying. Additionally, read the “Spotter’s Guide” on the right side of the screen.
- Classify by looking for candidates by matching up the radio contours to their galaxies images in the infrared:
 - 1) Examine the radio & infrared images;
 - 2) Identify the radio source components;
 - 3) Mark the location of the host galaxy.
- Mark your favorite objects
- Present them to your peers.

4. Wrap-up

Finally, we will discuss how your input is used and leads to a scientific publication (<https://arxiv.org/abs/1507.07272>).