Lay Summary – Report on the efficiency of AGN jets and evolution across cosmic time

My project focuses on the fascinating topic of active galactic nuclei (AGN) and their supermassive black holes (SMBHs). Imagine a galaxy as a bustling metropolis in space. Now, in the very center of this bustling metropolis lies its city centre, an AGN. At the core of this AGN resides a SMBH, which acts as the city's colossal energy generator. These cosmic giants are not just sitting idly in their host galaxy; they're actively consuming surrounding matter, emitting powerful jets of energy in the process. These jets, among other things, have a significant impact on their galactic surroundings, influencing star formation and even affecting the broader galactic environment.

We have reason to believe that there is a SMBH at the center of nearly every galaxy in the universe, so understanding their mechanics is very important. Some of these SMBHs are consuming so much matter that they can outshine their host galaxies. This shows just how powerful they can be, so understanding where this power comes from is a very interesting question. That's where my research comes in, I’m taking a fresh statistical approach to tackle this mystery.

By analysing and comparing X-ray and optical measurements of AGN, we're developing new ways to understand their radio and kinetic emissions. This allows us to calculate the average efficiency of different types of AGN jets, shedding light on their ability to influence their surroundings. Understanding the physics behind these jets is an important puzzle piece in finding how SMBHs generate and emit such massive amounts of energy.

My research focuses on the kinetic efficiency of SMBH jets, this tells us how efficient the central SMBH is at converting its consumed matter into the kinetic energy that propels the jets. In some cases I find that the process can be up to 60% efficient, much more efficient than even the process of nuclear fusion within the cores of stars, which is about 0.5%. This means that the jets are 120 times more efficient than the sun at converting matter to energy.

My findings also suggest that these cosmic giants don't operate in a one-size-fits-all manner. Instead, their impact varies across billions of years, with some showing an increase in their influence over time. This may occur due to changes in the amount of matter available for consumption or shifts in the surrounding environment of the SMBH. My results also suggest that not all of these giants are the same. They can differ in their structure and power, having varying degrees of influence on their galaxies and environments.

So why does this matter? Well, understanding the life cycles of SMBHs isn't just about curiosity; it has real implications for the evolution of galaxies. By uncovering more about these energetic processes, we could gain insights into how galaxies are formed, their interactions with neighboring galaxies and intergalactic space, and even how our universe as a whole evolves over time.

SMBHs play a role in regulating their host galaxies. For instance, their powerful gravity can affect the orbits of stars and other celestial bodies within the galaxy. Additionally, the energy released by SMBH jets can heat up the surrounding gas in galaxies, suppressing star formation in some regions while triggering it in others. This feedback loop between SMBHs and their host galaxies, known as AGN feedback, plays a crucial role in regulating star formation and shaping the overall structure of galaxies over time. Ultimately, my research could help answer some of the biggest questions in astrophysics, providing a clearer picture of the cosmic drama unfolding in the depths of space.