**Seminarium Astrofizyczne**  
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**From unveiling Giant Radio Galaxies to harnessing them as astrophysical probes**

Giant Radio Galaxies (GRGs) are galaxies hosting active supermassive black holes that

produce powerful bipolar radio jets, resulting in structures extending over megaparsec

scales. These are the largest single structures known in the Universe, with current research

indicating they can grow up to ~7 Mpc in size, surpassing even the dimensions of massive

galaxy clusters. Although GRGs were discovered 50 years ago, significant insights into them

have emerged only in the past eight years, largely due to the efforts of project SAGAN

('Search & Analysis of GRGs with Associated Nuclei'), which has been at the forefront of

understanding these enigmatic giant radio sources.

Research continues to investigate whether the immense sizes of GRGs are due to the high

efficiency of their powerful central active galactic nuclei (AGN), the sparser environments in

which they evolve, or a combination of both. To delve into the formation, growth, and

evolution of GRGs—and to assess their utility as probes of other astrophysical

processes—we initiated the dedicated project called ‘SAGAN’ in 2016. To date, 8 research

papers have been published from this project, including one review paper. These

publications have not only discovered the largest samples of GRGs, thereby dispelling the

myth of their apparent rarity but have also illuminated their key properties and refuted

some previously proposed models explaining their sizes. Our collective efforts through

project SAGAN and its results have inspired and rejuvenated interest in the field;

consequently, numerous research papers on the topic have been published by different

groups around the world.

In this seminar, we will present how our understanding of GRGs has been transformed over

the past eight years, thanks to the advent of deep radio surveys such as the LOFAR

Two-metre Sky Survey (LoTSS), which has been instrumental in discovering the largest and

faintest GRGs. We will discuss how using optical-infrared data from the Sloan Digital Sky

Survey (SDSS) and the Wide-field Infrared Survey Explorer (WISE), we studied the AGN

accretion properties of GRGs and compared them with those of normal-sized radio galaxies.

Additionally, we will describe how millimetre-wave data from the IRAM 30-metre telescope

was utilised to understand the fuelling of AGNs in GRGs. By employing multiple radio

surveys and conducting dedicated observations with all major radio telescopes, we

determined key radio properties of GRGs using large samples for the first time. We will

present high-quality radio images obtained from GMRT, unveiling previously unseen

low-surface-brightness radio structures in GRGs. These data, as part of our ongoing work,

have enabled more precise estimates of the ages and magnetic fields of these structures.

Using optical data, we constrained their environments and assessed how these affect their

growth, thereby disproving some previous models. Lastly, we will demonstrate how GRGs

have been—and can increasingly be—used as cosmic probes of the large-scale environment

and magnetic fields, which has significant implications for our understanding of

magnetogenesis.

The upcoming Square Kilometre Array (SKA) will achieve unprecedented sensitivity in

significantly shorter observation times, enabling us to discover more GRGs and study them

in greater detail. The SKA's advanced capabilities will allow us to detect the faintest and

most distant GRGs, shedding light on their role in cosmic evolution and the large-scale

structure of the Universe. Our future research with the SKA will further enhance the utility

of GRGs as cosmic probes, deepening our understanding of fundamental astrophysical

processes.

Serdecznie zapraszam,  
Kishan Deka, on behalf of the SOC