Dr. Surajit Paul (Invited talk: Radio Astronomy)

Title: Deciphering the oldest remnant radio lobes of a bright galaxy discovered inside the cluster Abell 980

Abstract:

Clusters of galaxies are excellent laboratories for studying recurring nuclear activity in galactic nuclei (AGN) as their hot gaseous medium can vastly prolong the detectability of AGN radio lobes via better confinement. It is well known that the different phases of the radio galaxy life cycle get unfolded through their radio spectral steepening. Certainly, an ultra-steep spectrum (USS) nature of the radio lobes indicates their dying phase. Furthermore, as the recurring nuclear activity in radio galaxies manifests through their radio jet emissions, if the life of the remnant radio lobes gets prolonged, it becomes easier to detect many phases of activity of these systems, mainly in the form of a new and an old pair of radio lobes. The ultra-steep and highly aged radio lobes are therefore the key to a better understanding of AGN life-cycle. In cluster galaxies, such sources also play a significant role in the formation of diffuse cluster radio sources and reveal the intricate details of the dynamics of intra-cluster medium (ICM).

In this talk, I will present our recent discovery of the interesting recurring nuclear activity of the brightest cluster galaxy (BCG) of Abell 980. This cluster reveals an unusually rich phenomenology as we analyse multi-band archival data from *Chandra* X-ray, GMRT (150 and 325 MHz), EVLA (1.5 GHz) and LoTSS-II (144 MHz) radio. It is shown to be a quasi-relaxed cluster with a cool core (T~4.2 keV) surrounded by a hot and extensive intracluster medium (ICM) at T~6.8 keV. The radio emission shows a rich diversity, having (i) two large diffuse sources of the ultra-steep spectrum (USS) extending to opposite extremities of the ICM, each associated with an X-ray brightness discontinuity (cold front); (ii) a bright radio-double of size ~55 kpc coinciding with the central BCG; and (iii) a diffuse radio source, likely a mini-halo of size ~110~kpc around the BCG which possesses a huge ellipsoidal stellar halo of extent ~80 kpc. The association of cold fronts with two USS sources having so far the record age of ~260 Myr located in a cool-core cluster makes it a very rare system. We successfully argued that these longest surviving radio lobes resulted from the better confinement of radio plasma by the unique condition facilitated by this relaxed and comparatively low-mass cluster with an unusually hot surrounding medium.

We further proposed that the cluster's radio emission in A980 comes mainly from two double radio sources produced by the brightest cluster galaxy (BCG) in two major episodes of jet activity. The two radio lobes left from the previous activity have become diffuse and developed an ultra-steep radio spectrum while rising buoyantly through the confining hot intra-cluster medium (ICM) and, concomitantly, the host galaxy has drifted to the cluster centre and entered a new active phase manifested by a coinciding younger double radio source. The arguments presented here by combining the highly sensitive and resolved maps of LoTSS-II and 235 MHz GMRT bolster the case that the old and young double radio sources in A980 conjointly represent a `double-double' radio galaxy whose two lobe-pairs have lost collinearity due to the (lateral) drift of their parent galaxy, making this system by far the most

plausible case of a `Detached-Double-Double Radio Galaxy' (dDDRG).