IISER Mohali Colloquium

Speaker: Professor Arif Babul

Title: The Formation and Evolution Massive Galaxies in the Cosmos and their Circumgalactic Environment

5:00pm, April 3, 2024
LH3, Lecture Hall Complex

Abstract: Contrary to many stereotypes about massive galaxies, the observed systems are diverse in their star formation rates, kinematic properties, and morphologies. Studying how they evolve into and express such diverse characteristics is an important piece of the galaxy formation puzzle. Here, we focus on a subset of massive galaxies, the brightest group galaxies (BGGs). We use a high-resolution cosmological suite of simulations based on the Romulus galaxy formation model, and compare simulated central galaxies in group-scale halos at $z = 0$ to their observed counterparts. Since most galaxy formation models are calibrated using measures that are strongly influenced by the properties and evolution of “normal” Milky-Way like galaxies, this exercise is also an opportunity to test the limits of these models. The comparison encompasses the stellar mass-halo mass relation, various kinematic properties and scaling relations, morphologies, and the star formation rates. We find Romulus BGGs that are early-type S0 and elliptical galaxies as well as late-type disk galaxies; we find BGGs that are fast-rotators as well as slow-rotators; and we observe BGGs transforming from late-type to early-type following strong dynamical interactions with satellites. In short, we find that Romulus reproduces the full spectrum of diversity in the properties of the BGGs very well. Additionally, due to its superb mass and spatial resolution, Romulus also offers a unique window onto the joint evolution of the BGGs and the surrounding intragroup medium. With respect to the latter, we are able to observe the emergence of multiphase structure - in the form of cold clouds - in the intragroup medium. Groups also experience repeated AGN feedback episodes that drive large-scale collimated outflows into the IGrM. While the present resolution does not allow direct exploration of the coupling between the clouds and the AGN jets, we argue that the clouds will cause the SMBHs (and hence, the jets) to change direction every so often. Returning back to the BGGs, we find that early type galaxies can rejuvenate by growing disks, in agreement with recent observations. However, we also note a tendency towards lower than the observed fraction of quenched BGGs, with increasing halo mass. The problem appears to be due to decreasing effectiveness of AGN feedback with increasing halo mass. Examining some of the other galaxy formation models, we find that they too run into trouble on the same scale — but in an opposite sense. I will conclude by discussing what we are to make of this and what the path forward looks like.

About the speaker: Arif Babul is a University Distinguished Professor at the University of Victoria in Canada. He received his PhD from Princeton in 1989. He was a NATO Science Fellow at IoA, University of Cambridge and has held faculty positions at New York University and University of Victoria.Over the years, he has made several groundbreaking contributions to the field of astrophysics and especially, to the study of the formation and evolution of galaxies, galaxy groups and clusters of galaxies.

In recognition, he has been awarded several prestigious awards and honours. Early in his career, he was elected U.S. National Academy of Science Kavli Fellow and last fall (Oct 2023), was elected Fellow of the American Physical Society. He is currently a University of Victoria Distinguished Professor; holds a Infosys Visiting Professorship at the Indian Institute for Science and was recently named a rare second-time recipient of the Leverhulme Visiting Professorship in the UK.