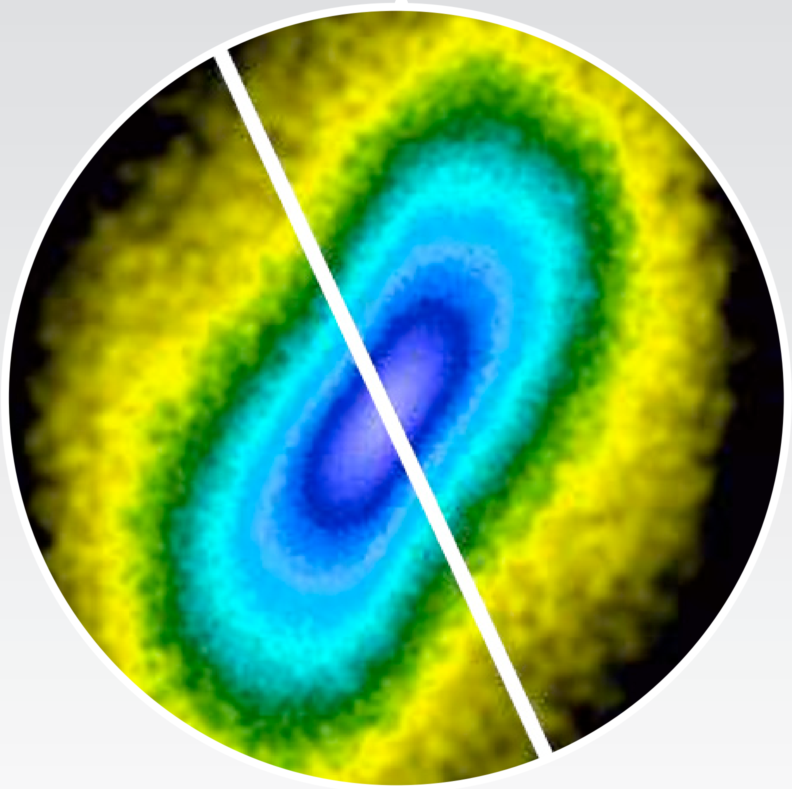
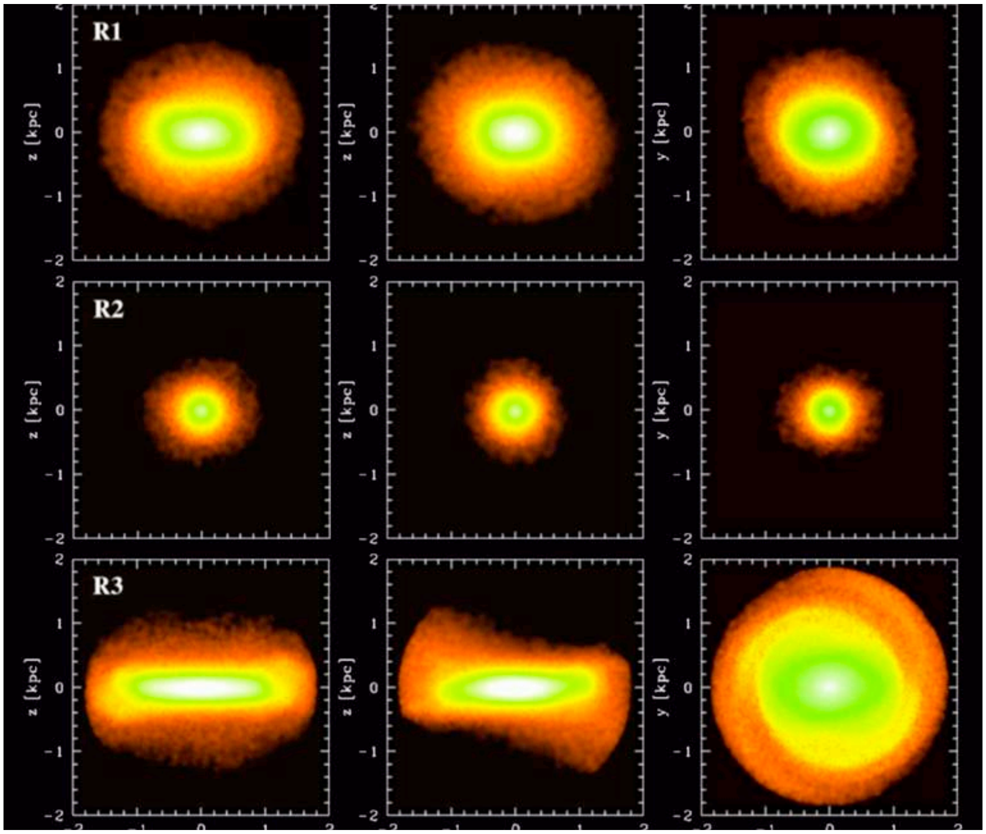


Ohio State's Stelios Kazantzidis employed Ohio Supercomputer Center systems to create a surface density map of the stellar distribution of a dwarf galaxy, with a line indicating the center of the host galaxy.

Research Landscape

Ohio's strengths in basic and applied research are broad and deep, spanning a multitude of academic, business and industrial interests. Likewise, the wide spectrum of clients served by the Ohio Supercomputer Center encompasses many fields of study. This diversity attracts eminent scholars and innovative entrepreneurs, as well as a wealth of regional, national and global research funding. Their research includes an astronomer who simulates the collisions of galaxies and black holes, researchers investigating techniques to provide more effective national security and a physicist who leverages supercolliders, supercomputers and a super-sized data network to unlock mysteries of the universe. The center strives to assist customers with basic needs, while simultaneously meeting the requirements of its most advanced customers, as evidenced by the significant projects described on the following pages.



left: Kazantzidis used Ohio Supercomputer Center systems to compile these three-panel surface density maps from three different simulations of the final stellar configurations of dwarf galaxies.

Kazantzidis **simulates effects of star formation**, black hole growth

Supercomputing centers allow astronomers to create extremely sophisticated models that are not feasible to build on desktop systems. However, simulating the multitude of elements involved in these galactic processes remains an enormous challenge.

"Our models can follow only a small subset of, say, the stars in a galaxy," explained Stelios Kazantzidis, Ph.D., a long-term fellow at Ohio State's Center for Cosmology and Astro-Particle Physics. *"For example, a galaxy like our Milky Way contains hundreds of billions of stars, and even the most sophisticated numerical simulations to date can simulate only a tiny fraction of this number. The situation becomes increasingly more difficult in simulations that involve dark matter. This is because the dark-matter particle is an elementary particle and, therefore, it is much less massive than a star."*

Leveraging Ohio Supercomputer Center resources, Kazantzidis' research teams simulated disk galaxies merging with supermassive black holes (SMBH). They found the mass ratios of SMBH pairs in merged-galaxy centers do not necessarily relate directly to the ratios they had to their original host galaxies, but are *"a consequence of the complex interplay between accretion of matter onto them and the dynamics of the merger process."* As a result, one of the two SMBHs can grow in mass much faster than the other.

Kazantzidis believes simulations of the formation of binary SMBHs have the potential to open a new window into astrophysical and physical phenomena that cannot be studied in other ways and might help to verify general relativity, one of the most fundamental theories of physics.

Kazantzidis and his colleagues also developed sophisticated computer models to simulate the formation of dwarf spheroidal galaxies, which are satellites of the Milky Way. The study concluded that, in a majority of cases, disk-like dwarf galaxies – known in the field as disky dwarfs – experience significant loss of mass as they orbit inside their massive hosts, and their stellar distributions undergo a dramatic morphological, as well as dynamical, transformation: from disks to spheroidal systems.

"These galaxies are very important for astrophysics, because they are the most dark-matter dominated galaxies in the universe," Kazantzidis said. *"Understanding their formation can shed light into the very nature of dark matter. Environmental processes, like the interactions between dwarf galaxies and their massive hosts, which we've been investigating, should be included as ingredients in future models of dwarf galaxy formation and evolution."* ■

Project lead: Stelios Kazantzidis, The Ohio State University

Research title: Simulating structure formation in the universe: From dwarf galaxies to supermassive black holes

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Web site: www.physics.ohio-state.edu/~stelios/