Formation and Evolution of Galaxies, Stars, and Planetary Systems: The Local Universe Astrophysics Roadmap

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One of the fundamental questions of astrophysical research is: "What was the sequence of events, beginning with the Big Bang and the formation of cosmic structure, that ultimately led to the formation of the Solar System, the Earth and the creation of life?" A corollary to this question is: "How unique is the Earth as a cradle of and home to life?"

Understanding how galaxies, stars and planetary systems form and evolve is a critical component to addressing these fundamental questions. The details of star formation, stellar evolution, the interactions of stars with the interstellar environment, and the ultimate fate of stars must be better known to achieve this understanding. The local universe, namely the Milky Way Galaxy and the nearest galaxies, provide an excellent laboratory for these detailed studies, but higher spatial resolution, higher spectral resolution, higher time resolution over a broader spectral range than possible today are all necessary ingredients for progress.

High spectral resolution (~ 1 km/s) observations of molecular and atomic spectral lines provide the information needed to understand the lifecycle of the interstellar medium (ISM), from the formation of molecular clouds that partially collapse and produce clusters of stars, these stars' interactions with the local environment and eventual enrichment of the ISM with elements heavier than helium through mass loss, nova outbursts or supernova explosions. Large area maps of the MWG and nearest galaxies with heterodyne arrays in the FIR and submm will provide a 3D picture of the structure and kinematics of the ISM.

The earliest phases of star and planet formation occur in dusty, highly embedded environments. A large aperture, cooled IR-submm space telescope is required to observe and understand this critical period of star and planetary system creation. Such a facility will also be able to measure the brightness and period of an extremely large number of Mira, RR-Lyrae and Cepheid variables with sufficient time resolution across the Galaxy, providing precise distances and thus a 3D picture of the stellar component.

The principal mode of star and planet formation is in clusters, such as Orion or NGC3603. In order to observe and isolate the complex interactions and processes during the earliest epochs of star and planet formation with sufficiently high spatial resolution, a space-based IR interferometer (baseline of 50m or larger) is required.

Because we cannot observe the evolution of the cosmos and its contents directly – human timescales are orders of magnitude too short, *theory* is necessary not only as a necessary tool for converting observations of astrophysical plasmas into physical parameters but rather for "connecting the dots" of related objects, showing how these objects – planetary systems, stars, and galaxies – evolve in time. In 30 years computers will be about a thousand times faster with the ability to work with data sets that are larger by at least a similar factor. Numerical simulations with improved algorithms will allow realistic 3D models of evolution with complex microphysics to augment the improved observational capabilities thirty years from now to a greater extent than possible today.

10 years	ISM lifecycle: cloud formation and destruction; hidden components revealed
20 years	Understanding IMF of forming stars and planetary system properties
30 years	3D picture of the structure and kinematics of the Galaxy (stars, ISM, CRs,…)