CONDITIONS FOR LIFE IN THE LOCAL UNIVERSE

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Science Description

Some of the greatest outstanding scientific questions of our day are connected to the existence of life in the Universe, the necessary conditions for this and its sustainability. An underpinning factor is the creation of the elements and the flow of this material within our own and other galaxies leading to the birth of stars and planetary systems, leading perhaps to the environments needed for life to be established. The pieces of the scientific jigsaw puzzle that will ultimately lead to a complete understanding are broad in temporal and spatial scope, encompassing the earliest phases of the Universe, observed at high red shift, through to the galactic environment of the Solar System within as little as a few parsecs. This RFI response addresses the "local" aspect of the cosmic feedback and flow of baryons to support life, assuming that other elements will be considered in complementary submissions.

The Sun and several nearby stars are embedded in a complex of warm (~7000 K) and partially ionized interstellar clouds. In turn, this complex resides in an unusually low neutral gas density part of our Galaxy, a ~100 pc diameter rarefied cavity often termed the 'Local Bubble'. This region is filled with a diverse population of stars and its structure has been influenced by their lifecycles, which have, conversely, been affected by the environment in which they exist. We need to understand this cosmic feedback system within the local bubble and how it ultimately influences the habitability of our region of the Galaxy. This requires an understanding of the physics that controls the evolution and characteristics of hot atmospheres and coronae and the resulting interplanetary environment, linking the effects of stellar activity to habitability in stellar planetary systems. It addresses three key aspects of the COR program.

- What are the mechanisms by which stars and their planetary systems form?
- How are the chemical elements distributed in galaxies and disperse in the circumgalactic and intergalactic medium?
- How does baryonic matter flow from the intergalactic medium to galaxies and ultimately into planets?

The formation and evolution of stars, their interaction with interstellar material and the ultimate effect of all the various physical processes on their planetary systems is still poorly understood. Crucial elements of the picture concern the levels of activity in main sequence stars and the resulting stellar winds, which can directly affect planetary environments on a range of timescales. In addition, stellar winds control the flow of material and flux of cosmic rays from the galactic environment, which also have a potential influence on climate. Ultimately, stars recycle material back into the ISM enriching galactic metal content, through the production of white dwarfs and supernovae. All the important processes involved in these stellar lifecycles are traced by the presence of hot (10^5-10^7 K) gas. The important atomic transitions associated with this high temperature material occur in the UV, making the availability of UV imaging and spectroscopy essential for this work.

Specific science questions to address are:

Examine the structure and dynamics of stellar coronae: to determine the origins and evolution of coronal activity over stellar lifetimes and the influence of this activity on exoplanet atmospheres, astrospheres and the ISM.

Study the evolution of white dwarfs: to examine the physical mechanisms controlling the atmospheric abundances and understand how important elements such as CNO are returned to enrich the interstellar medium; determine the incidence of circumstellar material associated with the disruption of remnant planetary systems.

Probe the structure & ionization of the Interstellar Gas in the Galaxy and in the local group: measuring density, temperature, ionization state, and depletion level of gas clouds along 100s of lines-of-sight. Study local bubble-like structures in external galaxies.

General instrument requirements

This programme requires a range of instrumental capabilities including high-resolution imaging and spectroscopy. The principle drivers for the instrument requirements are:

- Highest possible spectral resolution (R>100,000) to distinguish multiple interstellar cloud components in velocity space.
- High instrument effective area to keep exposure times low and allow large samples (100s to 1000s) of objects to be observed (targets mostly too spatially dispersed for multi-object spectroscopy).
- High resolution imaging, capable of studying 10s of parsec size structures in local group galaxies.
- Wavelength range 100-300nm.

M.A. Barstow – 10th August 2012

I am willing to attend and participate in a workshop if invited