Distribution of Matter in and around Galaxies

The chemical evolution of the Universe embraces aspects that reach deep into modern astrophysics and cosmology. From observed distributions of element abundances here on Earth and our Solar System, the study of stellar populations, the interstellar medium in the Milky Way and other galaxies we want to know how present and past matter is affected by various levels and types of nucleo-synthesis and stellar evolution and possibly trace this evolution back to the Big Bang. Until recently three major categories were be identified: the study of pre-mordial star formation including periods of super-massive black hole formation, the embedded evolution of the intergalactic medium (IGM), and finally the status and evolution of stars and the interstellar medium (ISM) in galaxies. Today a fourth category relates to our understanding of dark matter in relation with the previous three categories.

The X-ray band is particularly sensitive to K-shell absorption and scattering from high abundance elements like C, N, O, Ne, Mg, Si, S, Ar, Ca, Fe, and Ni as well as L-shell absorption of at least Fe. These elements are abundant throughout the universe. In order to diagnose ISMs and IGM properties a technique is applied that uses the principle of backlighting, where strong and distant X-ray sources produce a broad continuum, which is being absorbed by elements in various phases in the line of sight. Furthermore, like the Lyman α forest in the optical band, absorbers in the IGM can also produce an X-ray line forest along the line of sight in the X-ray spectrum of a background quasar allowing for spectroscopy to probe the WHIM.

The realization of high resolution X-ray absorption surveys – as implied by the current realities of explorer and mission opportunities – is now possible with technologies which are currently at or near (within 5 years) sufficient levels of technology readiness:

→ *high efficiency X-ray optics (segmented) with optical performance < 5"*
→ *high resolution X-ray gratings with R > 3000 for E < 1.5 keV*
→ *X-ray micro-calorimeters with R > 2000 for E > 1.5 keV*

1. Within the next 5 – 7 years we might utilize sub-orbital rockets to pursue specific science goals in the above categories and obtain sufficient technology readiness
2. Within the next 12 -15 years small explorer mission opportunities should be realized to pursue some limited surveys
3. Beyond 15 years we should be able to perform proper and deep surveys with the power of a Generation-X-type X-ray observatory

X-ray absorption spectroscopy is a powerful tool to study existing forms of matter in our Universe. The roadmap for the next 30 years needs to lead to means and strategies which allows us to perform such absorption surveys as effectively as surveys are now or in very near future quite common in astronomy pursued in other wavelength bands such as optical, IR, and sub-mm.