原子核物理学と天体物理学との融合

The Synergy Between Nuclear Physics and Astrophysics

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Recent advances in cosmology and simultaneous technological developments in experimental instrumentation have enlarged the scope of astronomy from its traditional mode of optical observations of atomic and molecular physics-based phenomena, to a complementary mode of neutrino observations of nuclear and particle physics-based phenomena. This talk will attempt to illustrate the synergy between astrophysics and nuclear physics using the example of neutrino astrophysics. Neutrino astrophysics bridges several subfields of physics that traditionally have been separated. It is an interdisciplinary area where input from nuclear physics, particle physics, and astrophysics is needed. The properties of the neutrino has at long last yielded to an intensive experimental assault. Evidence for neutrino mass and oscillations are now seen in the solar-neutrino spectrum, in atmospheric neutrinos, and in the reactor and accelerator neutrino experiments. There are many profound astrophysical and cosmological implications of these recent results. In particular, the neutrino mass scale indicated at by these new data implies that neutrinos form a significant (though subdominant) fraction of the matter on very large scales. This is tantalizing, since it is in accord with at least some interpretations of the WMAP observations of anisotropy in the cosmic microwave background radiation. The recent neutrino oscillation data may also have significant implications for our picture of core-collapse supernovae. There has been steady progress in recent years in our understanding of supernovae. It was shown that neutral-current neutrino-nucleus scattering from abundant nuclei in supernovae can produce less abundant species such as B^{11}, F^{19}, Li^{6} in significant amounts. Progress was made on explosion models both with prompt and delayed mechanisms, especially in understanding the role of convection. Neutrino re-heating of the shock was established as the most likely mechanism stabilizing the explosion. The expanding neutron-rich hot bubble formed between the neutrino-sphere and the shock wave is now considered to be a very plausible site for the r-process nucleosynthesis. In this talk theoretical nuclear physics research at Tohoku University in these areas will be discussed.