Contribution ID: **89** Type: **Oral**

The possibility of Q-balls as cosmological and galactic dark matter

The Cold Dark Matter (CDM) hypothesis accurately predicts structure formation on cosmological scales and fits the temperature fluctuations of the Cosmic microwave background (CMB) and large-scale structure. However, observations that probe the innermost regions of dark matter halos and the properties of dwarf galaxy satellites have persistently challenged CDM. In contrast, the Modified Newtonian Dynamics (MOND) hypothesis can explain a broad range of galactic events. However, MOND can not explain the complex shape of the CMB and matter power spectra. It appears that CDM and MOND are effective in almost mutually exclusive regimes. This leads to the question: Is there a physical mechanism where CDM and MOND share a common origin? This talk discusses that non-topological solitons —the Q-balls —formed in the early Universe can mimic CDM at the cosmological scales. In contrast, they mimic MOND at galactic scales in the late Universe. Specifically, we discuss that Q-balls can form in the radiation-dominated epoch naturally. We also put an upper bound on the number density of Q-balls, which depends on the charge of the Q-ball and the primeval small charge asymmetry. We then discuss the possibility of forming Bose-Einstein condensate and superfluid phases of matter by the Q-balls in the present Universe.

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Session Classification: Cosmology

Track Classification: Cosmology