Contribution ID: **36** Type: **not specified**

The masses of neutron-rich zinc isotopes and their impact on nuclear astrophysics

Monday 6 February 2006 16:20 (20 minutes)

Nucleosynthesis theory describes how elements and nuclides are formed in stellar evolution, e.g., violent processes like supernovae explosions. For the calculations of the various pathways from hydrogen to the heavier elements the nuclear properties of a large number of nuclides need to be known [1,2]. Especially in the case of the r-process, where elements heavier than iron are formed by rapid neutron capture, nuclear structure data of neutron-rich nuclides far from the valley of stability are required.

The path of the r-process is determined by and reflects nuclear structure. For example at the neutron shell N=50 it crosses through the waiting point nuclide 80Zn. Slight deviations in the nuclear physics parameters can lead to large discrepancies in the modeling of the subsequent nucleosynthesis processes. One crucial parameter is the mass of the nuclides, which enters the determination of neutron separation energies and the Q-values for the beta decays. They are thus essential for the study of the r-process.

With the Penning trap mass spectrometer ISOLTRAP at ISOLDE/CERN very precise and accurate mass measurements with relative mass uncertainties down to dm/m=8x10-9 can be achieved. Recently, the atomic masses of the neutron-rich zinc isotopes 71-81Zn have been measured. For the first time the masses of 79Zn and 81Zn have been determined. The new experimental data allow the investigation of nuclear structure at the neutron shell N=50 for low Z. The possible impact on nuclear astrophysics is discussed.

[1] M. Mukherjee et al., Phys. Rev. 93, 150801 (2004)
[2] D. Rodriguez et al., Phys. Rev. Lett. 93, 161104 (2004)

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Session Classification: Trapping for Nuclear Physics