Fission evidences Maxwell's demon on the nuclear level

Profiting from recent progress in the experimental knowledge of the nuclear level density, an old problem has been solved [1]: It has been a puzzle since the 1960th why a surplus of excitation energy inducing the fission process is found almost exclusively in the heavy fragment. Recent experimental results reveal that nuclei exhibit an essentially constant temperature up to excitation energies of at least 20 MeV [2] with a temperature parameter which is grossly proportional to $A^{-2/3}$ [3]. This implies that the two nascent fragments at scission experience an energy sorting: The "hotter" light fragment transfers essentially all its intrinsic excitation energy to the "colder" heavy fragment. This energy sorting manifests itself in the mass-dependent neutron yields. Fig. 1 shows data for neutron-induced fission of ^{237}Np with E_n = 0.8 MeV and E_n = 5.55 MeV as an example.

This is another proof that nuclear fission provides a unique laboratory for studying the properties of nuclear matter. The discovery of the energy-sorting mechanism [1], which uncovers the peculiar thermodynamical properties of two nuclei in thermal contact, is another counter-intuitive manifestation of quantum-mechanical properties of microscopic systems. The energy sorting reminds Maxwell's demon, however the process is driven by entropy and does not violate the Second Law of thermodynamics.

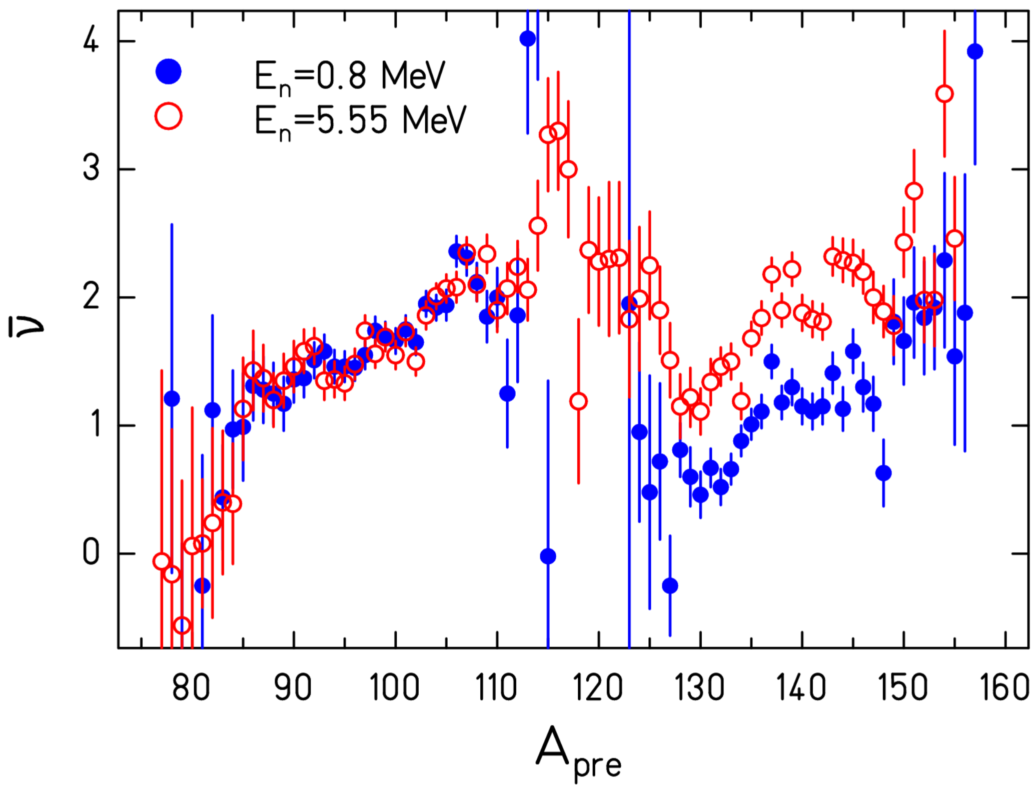

Figure 1 : Average number of prompt neutrons as a function of the primary fragment mass (before neutron emission) for the neutron-induced fission of ^{237}Np at two incident neutron energies, data taken from ref. [4]. The neutron yield at the lower neutron energy with its saw-tooth structure reflects mostly the energy gained by the relaxation of the deformation at scission to the ground-state shape of the fragments. The data reveal that all the additional energy of the incident neutron in asymmetric fission (A_{light} between 90 and 108 and A_{heavy} between 130 and 148) appears in the heavy fragment. The increase of the neutron yield at symmetry is due to another reason: The yield of the symmetric fission channel, which has a higher neutron yield, grows with increasing excitation energy.

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