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Evidence for a toroidal electric dipole mode in nuclei and implications for the pygmy dipole resonance

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I present first experimental evidence for a low-energy toroidal electric dipole mode in the nucleus ^{58}Ni based on a combined analysis of high-resolution (p,p'), (γ,γ') and (e,e') experiments [1]. Large transverse electron scattering form factors are identified as a unique signature of the toroidal nature of E1 transitions. Although ^{58}Ni is a nucleus with N ≈ Z, these results bear important implications for the nature of the pygmy dipole resonance (PDR) in heavy nuclei with neutron excess. The toroidal excitations carry the same experimental signatures as the states forming the PDR [2]: large isovector response (on the scale of low-energy E1 strength), strong isoscalar response and large ground-state branching ratios. QRPA models successfully describing the toroidal mode in ^{58}Ni predict the PDR in heavy nuclei to be of toroidal nature [3] and also reproduce the specific form of transition densities approximately isoscalar in the interior with a pronounced peak of the neutron density on the surface [4]. Furthermore, a recent study of the systematics of the low-energy dipole strength in the Sn isotope chain reveals much smaller B(E1) strengths of the PDR than previously thought [5]. These findings challenge an interpretation of the PDR as neutron skin oscillations implying a relation of the isovector strength to the neutron skin thickness and to the density dependence of the symmetry energy [6].

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