The E2 Resonance Effect in Antiprotonic Te Atoms and Evidence of the Level Width Saturation

B. Klos [a], S. Wycech [b], A. Trzcinska [c], J. Jastrzebski [c], T. Czosnyka [c], M. Kisielinski [c], P. Lubinski [c], P.J. Napiorkowski [c], L. Pienkowski [c], F.J. Hartmann, B. Ketzer, R. Schmidt, T. von Egidy, J. Cugnon [d], K. Gulda [e], W. Kurcewicz [e], and E. Widmann [f]

[a] Physics Department, Silesian University, PL-40-007 Katowice, Poland
[b] Soltan Institute for Nuclear Studies, PL-00-681 Warsaw, Poland
[c] Heavy Ion Laboratory, Warsaw University, PL-02-093 Warsaw, Poland
[d] Institut de Physique, Universite de Liege au Sart Tilman, B4000 Liege 1, Belgium
[e] Institute of Experimental Physics, Warsaw University, PL-00-681, Warsaw, Poland
[f] CERN, CH-1211 Geneva 23, Switzerland

The PS209 experiment investigating medium and heavy antiprotonic atoms was performed at CERN in 1995 and 1996. A part of the experimental results of these measurements have been published [1,2,3,4,5,6], other data wait for publication. In 2003 the analysis of the x-ray cascade from antiprotonic atoms of even-A Te isotopes: ^{122}Te, ^{124}Te, ^{126}Te, ^{128}Te, ^{130}Te was completed. Widths and shifts due to the strong interaction were deduced for $(n,l) = (8,7)$ and $(n,l) = (7,6)$ levels. The E2 nuclear resonance effect was observed in all investigated nuclei. In ^{130}Te the E2 resonance, predicted in [7], allowed to determine level widths and shifts of the LS-split deeply bound $(n,l) = (6,5)$ state, otherwise unobservable.

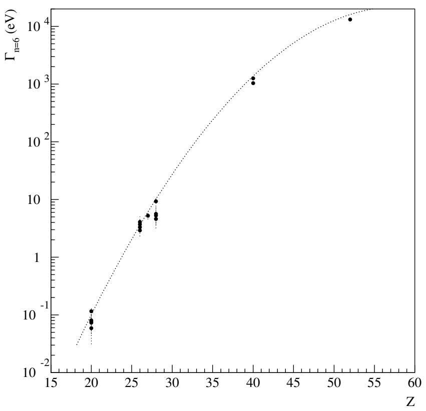

Fig. 1: The widths of the circular n=6 level [2], including the deeply bound level in ^{130}Te as a function of the atomic number Z. The line interpolates the widths calculated with the optical potential proposed in [8].

In Fig. 1 the systematics of the $n = 6$ level widths is shown and compared with optical model calculations. A clear saturation effect is observed for the widths with increasing Z value. The saturation effect is even better demonstrated in Fig. 2 where the level width was multiplied by B^{2l+3} (B - Bohr radius) removing the trivial consequence of atomic wave function normalization. This figure indicates the initial increase, saturation and ultimate damping of the absorption that follows the increasing penetration of the antiproton into the nuclear interior. Such a behavior, typical for strongly absorptive interaction, was already observed in very light nuclei. The ^{130}Te is the case with the largest atomic-nucleus overlap observed so far.

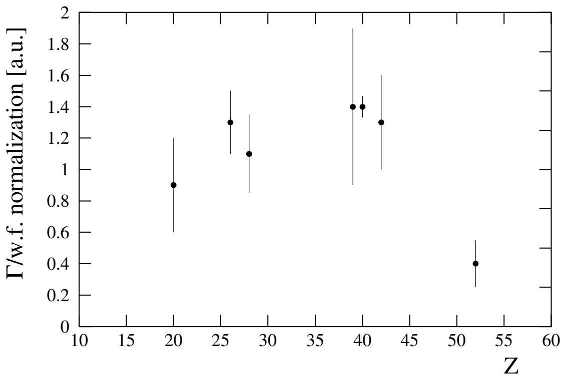

Fig. 2: The experimental widths of the circular $n = 6$ level (averaged over isotopes of a given element) scaled by the normalization factor of the atomic wave function (arbitrary units) plotted vs the atomic number Z.

References

[1] A. Trzcińska, *et al.*, Nucl. Phys. **A692** (2001) 176c
[2] A. Trzcińska *et al.*, Acta Phys. Pol. **B 32** (2001) 917
[3] A. Trzcińska *et al.*, Phys. Rev. Lett. **87** (2001) 082501
[4] R. Schmidt *et al.*, Phys. Rev **.** (C 58) 19983195
[5] F.J. Hartmann *et al.*, Phys.Rev. **C 65** (2002) 014306
[6] R. Schmidt *et al.*, Phys.Rev. **C 67** (2003) 044308
[7] M. Leon, Nucl.Phys. **A 260** (1976) 461
[8] C.J. Batty *et al.*, Nucl. Phys. **A 592** (1995) 487