Evidence for excitation modes of ^{11}Li from proton inelastic collisions

R. Crespo[(1)], I.J. Thompson [(2)] and A. Korsheninnikov [(3)]
(1) Departamento de Física, Instituto Superior Técnico, Lisboa, Portugal
(2) Department of Physics, University of Surrey, Guildford, Surrey, GU2 7XH U.K.
(3) RIKEN, Wako, Saitama 351-0198, Japan

The structure of the continuum of halo nuclei is a timely problem which can be addressed through inelastic scattering from stable nuclei. In particular, the existence of a new collective motion, the 'soft dipole' excited state or resonance at low energies in the breakup continuum predicted by some theories [1], remains today an open problem. Some evidence for these modes was found for ^{11}Li [2,3].

In this work, we analyse the evidence for low lying excited states in ^{11}Li in inelastic collisions from protons within the few-body Multiple Scattering expansion of the total Transition amplitude (MST) formalism [4] using three different few-body structure models for the ^{11}Li ground state: a s^2 model [5,6]; a p^2 model that would be expected from normal shell model ordering [7]; and a mixed *sp* model [8], which contains a superposition of $(0p_{1/2})^2$ and $(1s_{1/2})^2$ in good agreement with the values extracted in [9]. According to this model, a low lying resonance can be found for $J^\pi_{nn} = 0^+$, which has superpositions of s^2 and p^2 configurations orthogonal to those of the ground state. This, is not predicted in the case of the s^2 and p^2 models.

We show that the shakeoff framework used in [6] fails to describe both the shape and magnitude of the inelastic cross section and that MST reproduces well the differential cross section and the shape, position and magnitude of the peak in all the three structure models. On the other hand, the energy spectrum can only be reproduced by the *sp* model. Furthermore, the differential cross section and energy spectrum are essentially produced by a dipole excitation. However, there is a measurable contribution from the 0^+ excitation in the energy spectrum. This is the first evidence for this 0^+ resonance at 1-2 MeV excitation.

[1] Y. Alhassid, M. Gai and G.F. Bertsh, Phys. Rev. Lett. **49**, 1482 (1982).
[2] T. Suzuki, H. Sagawa and P.F. Bortignon, Nucl. Phys. **A662**, 282 (2000) and references therein.
[3] A.A. Korsheninnikov *et al*, Phys. Rev. Lett. **78**, 2317 (1997).
[4] R. Crespo and R.C. Johnson, Phys. Rev. C **60**, 034007 (1999); R. Crespo and I.J. Thompson, Nucl. Phys. **A689**, 559c (2001); R. Crespo, I.J. Thompson and A.A. Korshenninikov, submitted for publication.
[5] L. Johannsen, A.S. Jensen and P.G. Hansen, Phys. Lett. B **244**, 357 (1990).
[6] S. Karataglidis *et al*, Phys. Rev. Lett. **79**, 1447 (1997).
[7] G.F. Bertsch and H. Esbensen, Ann. Phys. **209**, 327 (1991).
[8] I.J. Thompson and M.V. Zhukov, Phys. Rev. C **49**, 1904 (1994).
[9] H. Simon *et al*, Phys. Rev. Lett. **83**, 496 (1999).