Helvetica Physica Acta, Vol. 51 (1978), Birkhäuser Verlag, Basel

Observation of the 15.1 MeV (1^+) state in carbon-12 by π^+ inelastic scattering near the πN (3, 3) resonance

by **C. Perrin**

Institut des Sciences Nucléaires, B.P. 257, Centre de tri, F-38044 Grenoble-Cedex, France,

R. Corfu, J.-P. Egger, J.-F. Germond, P. Gretillat, C. Lunke, J. Piffaretti and **E. Schwarz**

Institut de Physique, Université de Neuchâtel[1]), Rue A.-L. Breguet 1, CH-2000 Neuchâtel, Switzerland

(3.IV.1978)

We dedicate this article to Prof. J. ROSSEL for his 60th birthday.

Abstract. The 15.1 MeV (1^+) level in carbon-12 was observed by π^+ inelastic scattering off ^{12}C at 148 MeV and 58°. The differential cross-section is of the order of ≈ 40 μb/sr.

A few years ago it was pointed out by Wilkin [1] that for magnetic transitions such as the excitation of the 1^+, $T = 1$ level in ^{12}C at 15.1 MeV, the pion can be a useful probe, because there is the possibility of extracting relevant nuclear structure information. In the vicinity of the πN (3, 3) resonance, the pion-nucleon amplitude varies very rapidly with energy. This feature, which is quite different from electron or proton scattering, should in principle allow a separation of the orbital and spin contributions to the magnetic form factor. Below the (3, 3) resonance the contributions add constructively, above destructively. It should therefore be possible to pick out the coefficients of the two terms independently. In this paper we present the first observation of the 15.1 MeV state below the (3, 3) resonance.

The experiment was carried out at the SIN (Swiss Institute of Nuclear Research) πMl beam and pion spectrometer. A 2 mm thick natural carbon target was used. The apparatus and method used are described in Ref. [2]. The measured spectrum is shown in Fig. 1. The laboratory scattering angle chosen was 58°, corresponding to the first minimum of the elastic cross-section. The measurement of angular distributions in π^+–^{12}C elastic and inelastic scattering at 148 MeV [3] showed that the 15.1 state is generally excited very weakly. However it is clearly separated in Fig. 1, because the spectrum was shifted along the focal plane of the spectrometer. Momentum resolution was 700 keV FWHM. The differential cross-section is ≈ 40 μb/sr for the above state at 58° and 148 MeV.

[1]) Work supported in part by the Swiss National Science Foundation.

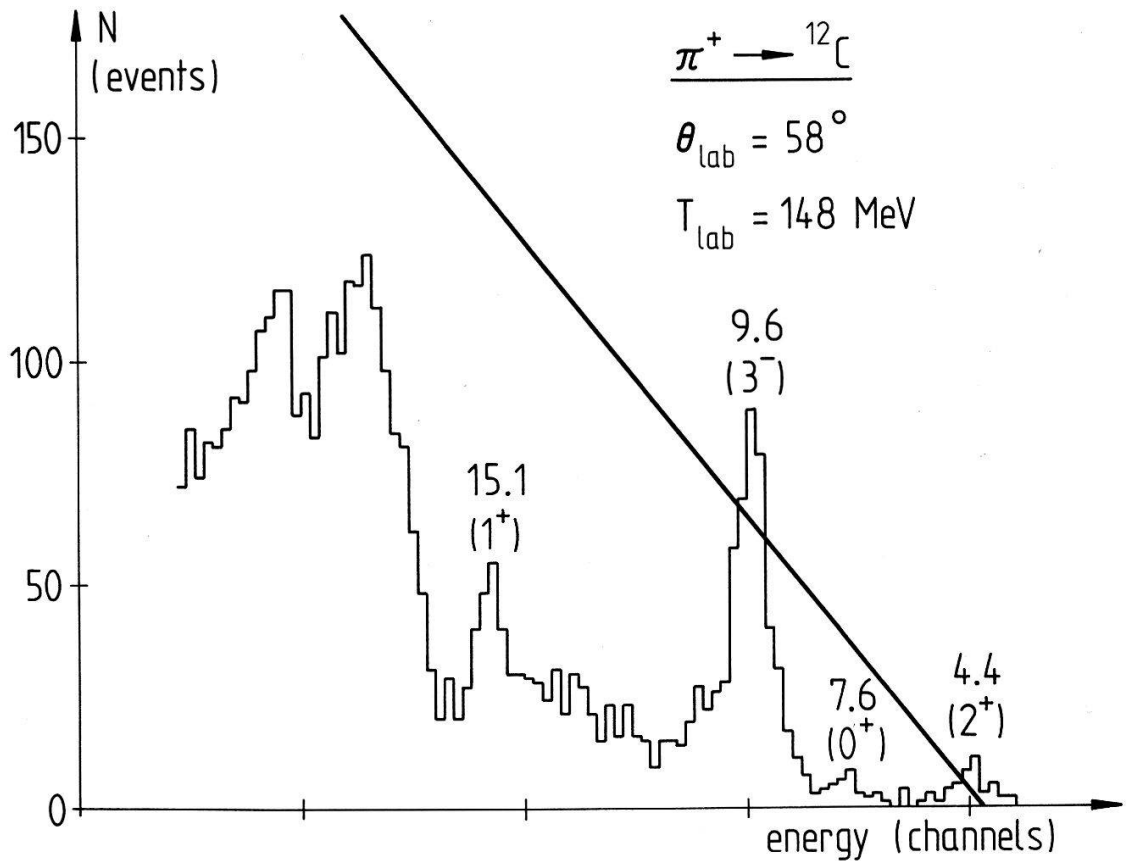

Figure 1
Pion scattering spectrum for 148 MeV π^+ on ^{12}C. The laboratory angle is 58° which corresponds to the first minimum of the elastic cross section. In addition, the spectrum was shifted along the focal plane of the spectrometer and not corrected for spectrometer acceptance, which is approximately rendered by the solid line. Although the 15.1 MeV (1^+) state is generally excited very weakly, it is clearly separated here.

Pion carbon elastic and inelastic scattering had been measured earlier at CERN [4] and some evidence was found for the excitation of states in the 15 MeV region. For reasons of momentum acceptance, the measurements extended to 15 MeV excitation energies only at $T_{lab} = 200$ MeV and above. However their momentum resolution did not allow for a separation of the 15.1 MeV state from the neighboring 14.1 (4^+) and 16.1 (2^+) states. In addition, the scattering spectrum of Fig. 1 shows some structure around 18 and 20 MeV and a contribution due to carbon break-up. Therefore the quoted cross-section of 0.41 ± 0.06 mb/sr [4] at 200 MeV and 50° lab. (first cross-section minimum for elastic scattering) obtained for a rather broad enhancement in the vicinity of 15 MeV is certainly too large. However, it is interesting to note that no significant evidence can be found in Fig. 1 for the excitation of the 1^+ state at 12.7 MeV excitation energy, a fact which is presently not understood.

A search for magnetic ($M1$) transitions was pursued at SIN [5] by the Karlsruhe group for pion scattering off ^6Li and ^{14}N. The corresponding excited states are at 3.56 MeV (0^+) for ^6Li and 2.14 MeV (0^+) for ^{14}N. However the observation of the 3.56 MeV state in ^6Li is obscured by a broad 2^+ state at 4.31 MeV and an important contribution due to the three body break-up of ^6Li. In the case of ^{14}N the situation should be cleaner. However no significant excitations of the two states above were reported by the Karlsruhe group.

In conclusion we report the first unambiguous observation of the 15.1 MeV (1^+) level in ^{12}C by pion scattering with a differential cross-section of ≈ 40 μb/sr at

148 MeV and 58° which is an order of magnitude lower than the value quoted by Binon et al [4] and roughly compatible with the prediction of Wilkin [1].

REFERENCES

[1] C. WILKIN, Nucl. Phys. *A220*, 621 (1974).
[2] J.-P. ALBANÈSE et al., Nucl. Instr., to be published; and in:
Proc. of the Carnegie-Mellon Conf. on Meson-Nucl. Phys. (1976) p. 724;
J.-P. EGGER et al., Phys. Rev. Lett. *39*, 1608 (1977).
[3] J. PIFFARETTI et al., Phys. Lett. *67B*, 289 (1977).
[4] F. BINON et al., Nucl. Phys. *B17*, 168 (1970).
[5] J. ZICHY et al., to be published.