Radiative Pion Absorption in Complex Nuclei (*)

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Summary. — We consider the process in which the nuclear absorption of a bound negative pion leads to the emission of a high-energy photon for the cases of nickel and tin. It is confirmed that this process will preferentially excite spin-isospin states in the final nucleus that are the isobaric analogs of states in the giant-resonance region of the initial nucleus. The distribution of spin-isospin strength among the states considered is presented, and it is found that the strength is considerably less fragmented than was the case for radiative pion absorption in calcium and zirconium.

1. Introduction.

The absorption into a complex nucleus of a bound negative pion usually proceeds through a reaction in which two nucleons are ejected. A small percentage of the time, however, a high-energy photon is emitted: this is the process known as radiative pion absorption.

In recent years, much of the interest in this reaction has centered on its connection with muon capture (1). Demonstrations (2-3) of the usefulness of

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this relationship for complex nuclei made use of the impulse approximation in order to identify the radiative pion absorption operator with the axial-vector-current operator of muon capture. These discussions for light nuclei emphasized that radiative pion absorption should preferentially excite spin-isospin states in the final nucleus that are the isobaric analogs of states in the giant-resonance region of the initial nucleus. These states are known to be of importance in determining muon capture rates \(^{(4)}\), and evidence for their role in this process, as well as the role of the isospin collective states has appeared in measurements of outgoing neutrons following muon capture \(^{(5)}\). The study of spin-isospin states can be carried out more directly in the radiative pion absorption reaction, since there the spectrum of the outgoing photon is experimentally accessible \(^{(6)}\). Recent experiments \(^{(7,8)}\) in which these energy spectra were measured seem to substantiate the role of the spin-isospin states for light nuclei.

Detailed calculations \(^{(9-10)}\) of radiative pion absorption in light nuclei, in which the pion is absorbed from the 1S or 2P atomic orbit, have made use of the «catastrophic» or Kroll-Ruderman \(^{(11)}\) term in the pion photoproduction amplitude, together with the impulse approximation, to describe the process. In a previous paper \(^{(12)}\), radiative pion absorption in heavier nuclei, in which the pion is absorbed from the 3D or 4F atomic orbit, was considered. These calculations made use of an operator \(^{(13)}\) which included corrections to the Kroll-Ruderman term. The results of this previous work \(^{(12)}\) demonstrated that the spin-isospin levels are appreciably excited in heavier nuclei and also that the corrections to the transition rate as given by the leading Kroll-Ruderman term are of the order of 20 to 30 per cent and do not appreciably modify the distribution of transition strength.

In the present work we extend our treatment of radiative pion absorption to nickel and tin in an attempt to determine the importance of the spin-isospin states for absorption in these nuclei.