Calculation of the Giant Monopole Resonance Using Relativistic Mean Field Theory *

LI Yan-Song[1,2] F. H. AL-Khudair[1,2] LONG Gui-Lu[1,2,3,4]

1(Department of Physics, Tsinghua University, Beijing 100084, China)
2(Key Laboratory For Quantum Information and Measurements, Beijing 100084, China)
3(Institute of Theoretical Physics, Chinese Academy of Sciences, Beijing 100080, China)
4(Center of Theoretical Nuclear Physics, National Laboratory of Heavy Ion Accelerator of Lanzhou, Lanzhou 730000, China)

Abstract Giant monopole resonances (GMR) are studied using a recently developed relativistic mean field theory computer code. We calculated the GMR energies of ^{16}O, ^{40}Ca and ^{208}Pb for both the isoscalar and isovector cases. Good agreement with experimental data is obtained.

Key words relativistic mean field, giant monopole resonance, RECAPS

1 Introduction

Recently we have written a new relativistic mean field computer code. It is used for the relativistic consistent angular-momentum projected shell-model (RECAPS). The RECAPS is a new nuclear model that combines the advantage of relativistic mean field theory and the projected shell model[1,2]. RECAPS is a self-consistent microscopic model and it is a new attempt for studying nuclear structure of normal nuclei and nuclei far from the stability. The basic ideas and some applications of RECAPS are given in Refs. [1,2]. In the RECAPS, the relativistic mean field has to be performed first to determine the shape and single particle energy level for a given nucleus, and later a small model space is chosen near the Fermi surface to calculate the excited structure. The new relativistic mean field computer code uses spherical harmonic function for expansion, and the new code RECAPS-RMF is more convenient for angular-momentum projection. It has been shown that RECAPS computer code is reliable in calculating the binding energies and single particle levels[1]. In this paper, we shall calculate the giant monopole resonance of ^{16}O, ^{40}Ca and ^{208}Pb nuclei, using the RECAPS-RMF code. The results agree with experimental data well.

2 Relativistic mean field

We will just give the basic idea about the calculation of GMR energy. Because GMR reflects the incompressibility of nuclei, calculating GMR energy is an important way to test whether the model used can describe the incompressibility of nuclei well. It is well known that RMF is an excellent model, which can reproduce the incompressibility of nuclei.

The Lagrangin density of RMF having a system with nucleons, mesons and photons has the form[3]

$$\mathscr{L}=\bar{\Psi}[i\gamma^{\mu}\partial_{\mu}-m-g_{\sigma}\sigma-g_{\omega}\gamma^{\mu}\omega_{\mu}-g_{\rho}\gamma^{\mu}\boldsymbol{\tau}\cdot\boldsymbol{\rho}_{\mu}- e\gamma^{\mu}\frac{1-\tau_3}{2}A_{\mu}]\psi+\frac{1}{2}\partial^{\mu}\sigma\partial_{\mu}\sigma-\frac{1}{2}m_{\sigma}^{2}-\frac{1}{3}g_2\sigma^3- \frac{1}{4}g_3\sigma^4-\frac{1}{4}\omega^{\mu\nu}\omega_{\mu\nu}+\frac{1}{2}m_{\omega}^2\omega^{\mu}\omega_{\mu}-\boldsymbol{\rho}^{\mu\nu}\boldsymbol{\rho}^{\mu\nu}\cdot\boldsymbol{\rho}_{\mu\nu}+ \frac{1}{2}m_{\rho}^2\boldsymbol{\rho}^{\mu}\cdot\boldsymbol{\rho}_{\mu}-\boldsymbol{\rho}^{\mu\nu}A^{\mu\nu}A_{\mu\nu}, \tag{1}$$

where the vectors are the isospin vectors and

$$\omega^{\mu\nu}=\partial^{\mu}\omega^{\nu}-\partial^{\nu}\omega^{\mu}, A^{\mu\nu}=\partial^{\mu}A^{\nu}-\partial^{\nu}A^{\mu},$$

Received 29 November 2003, Revised 29 March 2004

* Supported by NSFC(10047001, 10325521, 10347113), Major State Basic Research Development Program (G200077400), SRFDP Program of Education Ministry of China