

# 行政院國家科學委員會專題研究計畫 成果報告

強場對不同空間維數之費米子系統之量子效應(台俄國合計  
畫)(第2年)

研究成果報告(完整版)

計畫類別：個別型

計畫編號：NSC 95-2923-M-032-001-MY2

執行期間：96年10月01日至98年09月30日

執行單位：淡江大學物理學系

計畫主持人：何俊麟

計畫參與人員：教授-主持人(含共同主持人)：何俊麟

教授-主持人(含共同主持人)：Khalilov

報告附件：國際合作計畫研究心得報告

處理方式：本計畫可公開查詢

中 華 民 國 98 年 12 月 30 日

## **Final Report**

Under the support of this funding, I and Prof. Khalilov, co-PI from the Moscow State University of Russia, had studied the effects of Aharonov-Bohm potential and other external fields on particle with spin. The two major systems we considered are:

1. Scattering of spin-polarized electron in an Aharonov--Bohm potential;
2. Fermion pair production in planar Coulomb and Aharonov--Bohm potentials.

In the first year of the project, we considered the scattering of spin polarized electrons in an Aharonov—Bohm vector potential. We solved the Pauli equation in 3+1 dimensions taking into account explicitly the interaction between the three-dimensional spin magnetic moment of electron and magnetic field. Expressions for the scattering amplitude and the

cross section are obtained for spin polarized electron scattered off a flux tube of small radius. It was also shown that bound electron states cannot occur in this quantum system. The Aharonov-Bohm effect is an important phenomenon unique in quantum mechanics. Most works on this effect done previously by other researchers were mainly concerned with spinless particles. We believe our work will provide insights on further effects an Aharonov-Bohm potential could have on the scattering and bound states of spinning particles. This work was published in Annals of Physics [1].

Prof. Khalilov had visited Tamkang University from Jun 13 to Jul 4, 2007. During this period we had discussed considerably, and had finalized our first work mentioned before, and initialized the main approach to the second work, which was concerned with the problem of stability of a relativistic spin-one-half particle in a planar Coulomb and a Aharonov-Bohm potential. Then I visited Prof. Khalilov and the Moscow State University during Aug 27 to Sep 20, 2007. During this period we

completed the second work,

In this work, the exact analytic solutions and the eigenenergies were found for the Dirac equation in 2+1 dimensions for a spin-one-half particle in a combination of the Lorentz 3-vector and scalar Coulomb as well as Aharonov--Bohm potentials. We employed the two-component Dirac equation which contains a new parameter introduced by Hagen to describe the spin of the spin-1/2 particle. We derived a transcendental equations that implicitly determine the energy spectrum of an electron near the negative-energy continuum boundary and the critical charges for some electron states. Fermion pair production from a vacuum by a strong Coulomb field in the presence of the magnetic flux tube of zero radius was considered. It was shown that the presence of the Aharonov—Bohm flux tends to stabilize the system. Our result showed that one can manipulate the stability of such system with Aharonov—Bohm potential. This work was published in Chinese Journal of Physics [2].

## References

- [1] V.R. Khalilov and **C.-L. Ho**, Scattering of spin-polarized electron in an Aharonov--Bohm potential, *Ann. Phys.* 323, 1280-1293 (2008).
  
- [2] V.R. Khalilov and **C.-L. Ho**, Fermion pair production in planar Coulomb and Aharonov--Bohm potentials, *Chin. J. Phys.* 47 (3), 294 (2009).

本人此次並未動用赴俄羅斯莫斯科大學訪問之差旅費。我的說明如下。

我原定於 2008 年暑假訪問莫斯科大學一個月。後因獲得國科會通過補助本人於 2008 年訪問日本京都大學三個月，而我的學校規定三個月的短期訪問只能在暑假進行，故本人特向國科會申請將 95-2923-M-032-001-MY2 計畫的執行期限延後一年，以便我可以在 2009 年暑假訪問莫斯科大學。此申請獲得國科會通過。

赴俄簽證的申請需先由莫斯科大學開具邀請訪問證明至俄國外交部，再由俄國外交部發給本人簽證申請許可，本人方可至俄國在台辦事處申請簽證。故在計畫延期通過後，我即知會俄方共同主持人哈利洛夫教授(Prof. Khalilov)，並請他向莫斯科大學申請邀請本人訪問證明給俄國外交部。但遺憾的是，哈利洛夫教授的申請不被其校方通過，理由是本台俄雙邊計畫，台方雖已延至第三年，但俄方仍為兩年期限。因此，俄方已無理由邀請本人於第三年來訪！

由於俄國的官僚制度，至使本人訪問莫斯科大學的計畫告吹，而不得不忍痛將相關的差旅費交回。此事件不在我的能力控制範圍內，還請 貴會見諒！

本人此件台俄合作計畫，帶給我的是極不愉快的經驗。第一年訪問莫斯科大學期間，校方並未提供辦公室，也無網路連線，最後連給封邀請函的方便都要擺官架子（經費還是台方出的）。我只能說俄國官僚並不給予學者應有的基本尊重。我已將這些感受反應在台俄雙邊合作的調查表中。

以上就是我的說明。謝謝！