國立交通大學
National Chiao Tung University

出國報告（出國類別：學研訪問）

Visit to the Taras Shevchenko National University of Kyiv （Ukraine）
參訪烏克蘭基輔大學

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摘要

本次受基輔大學 無線電物理、電子及計算機系統院長之邀請前往參訪。目的將和研究領域相關學者分享本期在新穎半導體奈米結構之電子及光電特性與自旋電子應用之學術經驗，藉此交流提升此研究領域之發展。此外，並探討未來本中心與基輔大學在共同研究領域之學術研究合作計畫。

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本文

一、目的

Professor Igor Anisimov, the Dean of the Faculty of Radio Physics, Electronics and Computer Systems of the Taras Shevchenko National University of Kyiv (Ukraine) has invited me to visit his institution in the period from October 10th to October 18th, 2015. Professor Igor Anisimov suggested that this visit can provide with an opportunity to share research experience accumulated by research teams of professors from the Faculty and Prof. O. Voskoboynikov (National Chiao Tung University, Taiwan) in the field of the fundamental electronic and optical properties of novel semiconductor nanostructures. In addition Professor Igor Anisimov expressed his intention to explore the possibilities of future academic cooperation between our research groups and Universities in the fields of mutual interest. He stressed that this can support new approaches to research on complex and important topics of current interest for the Solid State Physics and Electronics community, such as novel semiconductor nanostructures for spintronic devices or other topics we find of common interest. I have accepted that invitation and visited the Dean of the Faculty of Radio Physics of the Taras Shevchenko National University of Kyiv (Ukraine) in the period from October 10th to October 18th, 2015.

Taras Shevchenko 國立大學（烏克蘭）無線電物理、電子與電腦系統學院的院長 Igor Anisimov 教授邀請我在 2015 年 10 月 10 號到 10 月 18 號這段期間去拜訪他的機構。Igor Anisimov 教授提出這個拜訪提供了一個機會讓他們學院研究團隊與 O. Voskoboynikov 教授（國立交通大學，臺灣）來分享彼此在新穎半導體的基礎電子與光學特性這個領域累積的研究經驗。此外 Igor Anisimov 教授表達了他的意願未來與我的研究團隊跟他的大學之間在彼此有共同興趣的領域進行更進一步的學術合作。他強調這可以支持新的方法來研究目前關於固態物理與電子領域複雜且重要的議題，像是新穎半導體奈米結構的自旋電子元件或是其他

我們發現共同興趣的議題。我接受了這個邀請並且於 2015 年 10 月 10 號到 10 月 18 號這段期間去拜訪他的機構。

The history of the Taras Shevchenko National University of Kyiv (Ukraine) dates back to 1833. Today the Taras Shevchenko National University of Kyiv is a classic university with a distinct research profile and the leading contemporary academic and educational hub of Ukraine. The high status of a classical research university is underpinned by the numerous academic achievements of its staff. The staff at the University have a broad range of formal achievements recognized, in particular with the State Prize of Ukraine in Science and Technology, Awards from the National Academy of Sciences of Ukraine and branches of the national academies of sciences, Orders of Merit, Orders of Saints Cyril and Methodius, awards of the honorary title of Honored Educationalist of Ukraine and Honored Lawyer of Ukraine, also Awards by the President of Ukraine for young academics and Awards by the Ukrainian Parliament to the most talented young scientists in basic and applied research, and scientific and technological development.

Taras Shevchenko 國立大學（烏克蘭）的歷史追溯到西元 1833 年，今天基輔的 Taras Shevchenko 國立大學是有著第一流研究形象及烏克蘭當代領導的學術及教育中心。一個一流大學的崇高地位是由他的職員許多學術成就所支撐的。這個大學的職員擁有很大範圍被正式承認的成就，特別是烏克蘭在科學與科技的國家獎項、從烏克蘭國家科學院及其他國家科學院分院得到的獎項、英國功績勳章、聖西里爾和聖美多德勳章、榮耀的獎項給予烏克蘭光榮的教育家與光榮的律師、烏克蘭總統給予年輕學者的獎項以及烏克蘭國會頒給在基礎和應用的研究、科學和科技發展最有天分的年輕科學家的獎項。


The main building of the Taras Shevchenko National University of Kyiv
基輔大學校園的教學大樓（基輔大學著名的紅色校園建築）

There are 13 Faculties within the University: Geography, Economics, History, Cybernetics, Mathematics and Mechanics, Sociology, Information Technology, Radio Physics, Electronics and Computer Systems, Psychology, Physics, Philosophy, Chemistry, Law. There are 8 Institutes (the Military Academy, the High Technology Centre, the Institute of Journalism, the Institute of Geology, the Institute of International Relations, the Postgraduate Education Centre, the Institute of Linguistics, and the State Security Department) and 1 Training and Research Center (the Institute of Biology), 2 Colleges (Optical and Mechanical College, Geological Exploring College), Ukrainian Physical and Mathematical Lyceum. Kyiv University has a number of other facilities, including: a Ukrainian Studies Centre, a Geological and Zoological Museum, a Museum of the University History, an Interfaculty Museum of Linguistics, an Informatics Centre, an Astronomical Observatory, a publishing and reprographics unit called "Kyiv University", and the Maksymovych Academic Library.

The University awards Junior Specialist's, Bachelor's, Specialist's and Master's degrees, Higher Qualification Post-graduate degrees and Doctoral degrees. Training and retraining programs are provided in 14 specialties of Junior Specialist qualification, 55 fields of Bachelor training programs, 49 areas of Specialist training

programs and 98 fields of Master training programs. More than 26 thousand students study at the University. Approximately 1,645 postgraduate students and 125 PhD students are working for higher qualifications at the University. Over 350 doctoral and higher postgraduate theses are submitted annually at the university. Courses are provided by 198 Departments. The academic potential of Kyiv University is today demonstrated by more than 60 full members and corresponding members of the National Academy of Science of Ukraine, 626 members of staff with Doctor's degrees and 1,645 staff with higher postgraduate degrees.

這個大學裡面有 13 個學院，地理學院、經濟學院、歷史學院、控制學院、數學與機械學院、社會學學院、資訊科技學院、無線電物理、電子與電腦系統學院、心理學學院、物理學院、哲學學院、化學學院及法律學院。8 個研究所(軍事學術研究所、高級技術研究所、新聞研究所、地質研究所、國際關係研究所、研究生教育研究所、語言學研究所及國家安全研究所)和 1 個訓練研究中心（生物研究所）、2 個學會（光學與機械學會、地質探索學會）、烏克蘭物理及數學學會。基輔大學有許多其他機構，包括一個烏克蘭研究中心、一個地理學及動物學博物館、一個大學歷史博物館、一個院系內的語言學博物館、一個資訊中心、一個天文觀測台、一個稱作〞基輔大學〞出版與複印的單位以及 Maksymovych 學術圖書館。

這個大學頒發初階專家、學士專家及碩士的學位，更高階認證的研究生學位及博士學位。在初階專家認證有 14 個專業訓練與再訓練的課程被提供、55 個學士訓練課程領域、49 個專家訓練課程領域及 98 個碩士訓練課程領域。比 26000 個還多的學生就讀於這個大學、大約有 1645 個研究生及 125 個博士生在這間大學攻讀更高的資格認證、超過 350 篇博士及碩士的論文每年被提出、198 個系提出課程。今天基輔大學的學術潛力藉由超過 60 個烏克蘭國家科學院正式及通訊成員所展現，626 成員有個博士學位、1645 個成員有著碩士學位。

The Maksymovych Academic Library at the University

大學內的 Maksymovych 學術圖書館

Today the University has bilateral partnership agreements with 227 foreign educational and scientific institutions from 57 countries. 180 foreign academics and lecturers from 32 countries visit the University annually to collaborate in research, attending conferences, and giving lectures. Each year more than 1500 lecturers, researchers and students travel abroad to 59 countries. Two-thirds of those take overseas trips in a year travelled abroad for academic purposes (conferences, training, and research).

今天這所大學與在 57 個國家中的 227 個國外教育及科學中心有著雙向夥伴關係協議。每年有從 32 個國家來訪的 180 位外國學術與演講員來進行學術合作、參加會議與給予課程。每年超過 1500 演講員、研究員級學生出訪到 59 個國家，每年 2/3 的這些人為了學術目的（會議、訓練及研究）而進行海外旅程。

The Taras Shevchenko National University of Kyiv is a classical university with a research profile, whose primary objectives are education, research and innovation.

基輔的 Taras Shevchenko 國立大學是一個有著第一流研究形象的大學，主要的目標是教育、研究及創新。

二、過程

In the Taras Shevchenko National University of Kyiv I was visiting the Faculty of Radio Physics, Electronics and Computer Systems and Institute of High Technologies.

我在基輔的 Taras Shevchenko 國立大學拜訪了無線電物理、電子與電腦系統學院及高科技中心。

The Faculty of Radio Physics, Electronics and Computer Systems in the main campus of the University

在大學主要校區的無線電物理、電子與電腦系統學院

The Faculty of Radio Physics, Electronics and Computer Systems was founded in 1952. From the beginning Faculty aims to train high skilled specialist, expected to combine a profound fundamental backgorund in physics and mathematics with engineering schooling in the field of radioelectronics as well as in closely related branches of science. The Department of Radio physics is as old as the Faculty itself. The Faculty consists of 7 Departments:

Physical Electronics. Main directions of study — plasmic and emissive electronics, sensor, plasmic chemistry etc. The oldest department of the faculty was founded in 1932 together with other special physical departments of the recommenced Kiev University under an initiative of the corresponding member of the Academy of Sciences Ukraine SSR. The Department has scientific cooperation with the Eindhoven

Technical University (The Netherlands), FOM Institute for Plasma Physics (The Netherlands), and Nagoya University (Japan). Prof. Igor Anisimov is the head of this department.;

無線電物理、電子與電腦系統學院成立於 1952 年。最一開始這個系的目標是訓練高技能的專家，期待以工程的學校教育去結合深厚基礎的物理與數學背景在無限電子領域與其他相近的科學分支。無線電物理系跟學院一樣老。這個學院包含了 7 個學系：

物理電子，主要的研究方向— 電漿及放射電子、感應器、電漿化學等。由烏克蘭共和國科學院的通訊成員主動的行動，這個學院最老的系所與其它重新開始的基輔大學的特殊物理學系一起建立於 1932 年。這個學系與 Eindhoven Technical 大學（荷蘭）、FOM Institute for Plasma Physics（荷蘭）和 Nagoya Universit（日本）有學術的合作。這個系目前的領袖是 Igor Anisimov 教授。

Quantum Radiophysics. Main directions of study — acoustooptics, microwave electronics, spin-waves electrodynamics, fiber optics, microsopy of near-field, integrated magnetooptics etc. Quantum Radiophysics Department works on contacting with leading profile laboratories of different countries and this provides the high level of scientific and educational activity;

Computer Engineering. Main directions of study — tunnel electron microscopy, solar power engineering, logical design for computer network etc. The Department keeps tight scientific relations with scientists from France, Germany, Slovakia, Spain, Poland, Italy, Taiwan and others, with whom joint work is conducted within the framework of European grants and bilateral agreement of cooperation;

量子無線電物理，主要的研究方向－聲光學、微波電子、自旋波電動力學、光纖光學、近場顯微及整合此光學等等。量子無線電物理系致力與其他國家主要的實驗室保持聯繫，而這提供了高水準的科學與教育活動。

電腦工程，主要的研究方向－穿隧電子顯微、太陽能源工程、電腦網路的邏

輯設計等等。這個學系與來自法國、德國、斯洛伐克、西班牙、波蘭、義大利、台灣和其他國家保持緊密的學術關係，在歐盟的獎助金與雙邊學術合作的架構下進行共同工作。

Medical Radiophysics. Main directions of study — intrascopy [imaging], telemedicine, visualization and analysis of medical images. The department maintains scientific relations with leading research institutions of Ukraine and in the world, particularly with Kharkov University, Dnepropetrovsk University, Universities of - Ghent (Belgium), Münster, Aachen, Frankfurt, Munich (Germany), Lyon (France), Normal, Maryland, Yale (USA), Vienna (Austria).;

醫學無線電物理，主要的研究方向－內顯（影像）、遠距醫療、醫學影像視覺化與分析。這個系與烏克蘭和世界的主要研究機構保持關係，特別是 University 大學、Dnepropetrovsk 大學、Universities of – Ghent（比利時）、Münster, Aachen、法蘭克福市、慕尼黑（德國）、里昂（法國）、Normal、馬裏蘭州、耶魯（美國）、維也納（奧地利）。

Electrophysics. Main directions of study — nanostructures, magnetooptics, spectroscopy. Research laboratory maintains relations with scientific institutions in the USA, Russia, Germany;

電子物理，主要的研究方向－奈米結構、磁光學、光譜學。研究實驗室與美國、俄羅斯與德國的科學機構保持關係。

Nanophysics and nanoelectronics. Main directions of study — high-temperature superconductivity, analysind phenomena ocurring in microminiature and microwave radiocircuits, constructing the systems of holographic recording and data displaying, computer data processing;

奈米物理與奈米電子，主要的研究方向－高溫超導體、微小型與微波微波電

路內出現的分析現象、建立全像術紀錄與資料顯示的系統和電腦資料處理。

Mathematics and theoretical radiophysics. Main directions of study - differential and integral equations, rheology, nonlinear mechanics etc.

數學與理論無線電物理，主要的研究方向－微分與積分方程式、流變學和非線性力學等等。

The Institute of High Technologies (IHT) has the status equal to that of a faculty. We offer B.Sc. programs in four fields of study: Physics, Applied Physics (with advanced level of Chemistry and Biology), Chemistry (with advanced level of Biology and enhanced Physics & Math training), and Biology (with advanced level of Chemistry and enhanced Physics & Math training). Further, IHT offers a Masters program in High Technology, which is open for students with a B.Sc. degree in any field of Physics, Applied Mathematics, Chemistry, or Biology. The Institute consist of 4 Departments:

Department Nanophysics of Condensed Matter. Main directions of study - fundamental relations between the chemical composition, atomic structure, and microstructure, on the one side, and macroscopic properties of devices, on the other. The Department collaborates with Institut des Nanotechnologies de Lyon (France), Helmholtz-Zentrum, Berlin (Deutschland), St. Petersburg State University (Russia), Aston University, Birmingham (United Kingdom).

高科技中心（IHT）與這個學院有相同的地位。在 4 個領域提供了學士課程，物理、應用物理（高等的化學與生物水平）、化學（高等的生物與加強物理與數學訓練水平）和生物（高等的化學與加強物理與數學訓練水平）。此外，IHT 在高技術提供了碩士課程，對任何在物理、應用數學、化學或生物的學士學位的學生開放。這個機構包含了 4 個系：

奈米物理與凝態物質系，主要的研究方向－一方面在化學成分、原子結構和微結構間基礎的關係，另一方面在元件巨觀的特性。這個系與 Institut des

Nanotechnologies de Lyon（法國）、Helmholtz-Zentrum（柏林/德國）、St. Petersburg State University（俄羅斯）和 Aston University（伯明翰市/英國）進行合作。

Department of Supramolecular Chemistry. Main directions of study - supramolecular complexes by modern analytical methods; search for biologically active compounds; photonics of organic molecules; synthesis and study of peptides and peptidomimetics; structural studies of peptides in biomembranes; design of new multifunctional materials; chemoinformatics.

超分子化學系，主要的研究方向－現代分析方法的超分子複雜物、尋找生物活性合成物、有機分子的光子學、肽及擬肽物的合成與研究、在生物膜中的肽的結構研究、設計新的多功能物質、化學資訊學。

Department of Theoretical Foundations of High Technologies. Main directions of study - near-field physics; physics of low-dimensional electronic, magnetic, and atomic systems, physics of nanocomposites, nanomagnetism, magnetoplasmonic systems. The Department collaborates with the Technische Universität Chemnitz, University of Bayreuth Helmholtz-Zentrum Dresden-Rossendorf (Germany), University of Aalborg (Denmark), University of Groningen (the Netherlands),

高科技理論基礎系，主要的研究方向－近場物理、低維度電子的物理、磁學和原子系統、奈米複合物的物理、奈米磁學、電漿磁光系統。這個系與 Technische Universität Chemnitz、Bayreuth Helmholtz-Zentrum Dresden-Rossendorf 大學（德國）、Aalborg 大學（丹麥）和 Groningen 大學（荷蘭）進行合作。

Department of Molecular Biotechnology and Bioinformatics. Main directions of study - structural analysis of highly conservative proteins and study of their specific affinity. Classical (sequence analysis) and structural (structure analysis and behavior particularity) bioinformatics of the different type of nucleotide binding proteins.

The international cooperation of the Faculty of Radio Physics, Electronics and Computer Systems and Institute of High Technologies has been performed with obvious success.

分子生物科技及生物資訊系，主要的研究方向－高保存性蛋白結構分析與研究他們特殊的親和力、不同種類核苷酸結合蛋白的古典（序列分析）和結構的（結構分析和行為特定性）生物資訊。

無線電物理、電子與電腦系統學院及高科技中心國際合作的已經明顯成功的執行。

Meeting in the Dean's office of the of Radio Physics, Electronics and Computer Systems. From the right: Prof. V. Chernyak, Prof. V. Kovalenko, Prof. I. Anisimov, Prof. O. Prokopenko, Prof. O. Voskoboynikov, and Prof. S. Zagorodnyuk

無線電物理、電子與電腦系統學院主任辦公室的會議

從右邊開始: V. Chernyak 教授、V. Kovalenko 教授、I. Anisimov 教授、O. Prokopenko 教授、O. Voskoboynikov 教授和 S. Zagorodnyuk 教授

三、心得及建議

During my visit I’ve performed the extensive discussions with professors of the Faculty of Radio Physics, Electronics and Computer Systems: Prof. N. Nakhodkin (academician of the National Academy of Science of Ukraine), Prof. I. Anisimov, Prof. O. Prokopenko (Chair of the Department of Nanophysics and nanoelectronics),

Prof. V. Boretskiy (Deputy dean in charge of international relations), Prof. V. Hryhoruk (Chair of the Department of Quantum Radiophysics), Prof. G. Martysh (Chair of the Department of Medical Radiophysics), Prof. V. Visotskiy (Chair of the Department of Mathematics and theoretical radiophysics), Prof. V. Kovalenko (Chair of the Department Electrophysic), Prof. V. Chernyak, Prof. A. Konovalov, Prof. V. Kislenko. In the Institute of High Technologies I met with: Prof. V. Ilchenko (Director of the Institute), Prof. V. Skryshevsky (Chair of the Department Nanophysics of Condensed Matter of the Institute), Prof. D. Sheka. In the meetings we very productively have shared our educational and scientific experience. I've have been involved in the mutual knowledge sharing with the scientific staff of the Faculty of Radio Physics, Electronics and Computer System during few meetings organized by Prof. I. Anisimov and Prof. V. Ilchenko.

在這段拜訪時間我與無線電物理、電子與電腦系統學院的教授們進行了廣泛的討論，N. Nakhodkin 教授（烏克蘭國家科學院院士）、I. Anisimov 教授、O. Prokopenko 教授（奈米物理與奈米電子系主任）、V. Boretskiy 教授（副院長/負責國際關係）、V. Hryhoruk 教授（量子無線電物理系主任）、G. Martysh 教授（醫學無線電物理系主任）、V. Visotskiy 教授（數學與理論無線電物理系主任）、V. Kovalenko 教授（電子物理系主任）、V. Chernyak 教授、A. Konovalov 教授、V. Kislenko 教授。在高技術中心我與下面這些人見面，V. Ilchenko 教授（中心主任）、V. Skryshevsky 教授（中心的奈米物理系所屬之凝態物質主任）、D. Sheka 教授。在這些會議中我們很有效率的分享了我們教育及科學的經驗，我在幾個由 I. Anisimov 教授和 V. Ilchenko 教授所主持的會議中參予了與無線電物理、電子與電腦系統學院的科學成員進行彼此知識的交換。

In the Faculty of Radio Physics, Electronics and Computer System. From the right: Prof. V. Ilchenko, Prof. O. Voskoboynikov, Prof. V. Skryshevsky, Prof. V. Kislenko

在無線電物理、電子與電腦系統學院，從右邊開始: V. Ilchenko 教授、O. Voskoboynikov 教授、V. Skryshevsky 教授、V. Kislenko 教授

Friendly discussion of Prof. O. Voskoboynikov and Prof. I. Anisimov

Prof. I. Anisimov 教授與 O. Voskoboynikov 教授友善的討論

Special attention was concentrated upon the exploration of the possibilities of the future academic cooperation between our research groups and Universities in the fields of mutual interest, specifically – theory of the semiconductor nano-structures and nonlinear phenomena in nanomagnetism. In addition a cumulative discussion was performed with members of research groups of Prof. V. Ilchenko and Prof. D. Sheka on the common experience, problems, and solutions for theoretical description and high performance computation with in the field of semiconductor nano-physics and nonlinear phenomena in nanomagnetism. Few important and difficult problems with

the package have been resolved.

我們特別注意在探討未來我們的研究團隊與他們的大學在彼此有興趣的領域進行學術合作的可能性，特別是半導體奈米結構的理論與奈米磁學中的非線性現象。此外我與 V. Ilchenko 教授和 D. Sheka 教授研究室的成員們進行了累積性的討論關於在半導體奈米物理及奈米磁學中非線性現象領域的理論描述及高效能的計算共同經驗、問題和解答。幾個重要而且困難的問題整組被解決。

Prof. V. Ilchenko and Prof. O. Voskoboynikov in the building of the Taras Shevchenko National University of Kyiv

V. Ilchenko 教授和 O. Voskoboynikov 教授在基輔 Taras Shevchenko 國立大學的建築物內

After our extensive discussions we have traced few directions of possible future collaboration. Among them I mention here: an important problem of the correct introduction of the vector potential to the Hamiltonian of the nano-system including semiconductor nano-objects and nanomagnets and correct formulation of simulation problems relevant to the simulation of the spin-interaction impact on the magnetic and magneto-optical response of three dimensional semiconductor nano-objects and nanomagnets with complex characteristics (which is essential in development of novel semiconductor and magnetic nanostructures for spintronic devices).

On the base of the reported above I can conclude that all primary goals of the visit have been successfully fulfilled.

在我們廣泛的討論之後我們描繪了幾個未來可能合作的方向，在這之中我在這邊提出：一個重要的問題關於正確引進半導體系統（包含了半導體奈米物體及奈米磁學）哈密頓函數的向量勢，以及對有著複雜特性的三維奈米物體及奈米磁學中在磁性及磁光響應下它自旋交互作用影響相關的一些模擬問題提出正確的公式化（對於發展新穎半導體奈米結構的電子自旋元件是必須的）。基於以上的報告我可以總結所有在這趟拜訪中的主要目的都被成功地完成了。

I have to note that the international collaboration problems, strategy and goals in the Faculty of Radio Physics, Electronics and Computer Systems of the Taras Shevchenko National University of Kyiv have much in common with those of the Department of Electronics Engineering of the National Chiao Tung University. For instance the project ultimate aim is, among others, to promote a growth process smart, sustainable and inclusive the Kiev Region of Ukraine, and establish itself as a hub of international Taras Shevchenko National University of Kyiv educational offerings as a specific educational model; to increase quality research outcomes; to enhance transfer to international companies; to maintain the University’s active role as an agent of social change; to continue as a benchmark for quality science. This experience effectively could be shared among our Universities. This can help to work towards an integral education for people who should find, within our community, the environment, the resources and the right encouragement to strengthen their capabilities and vocation through specific training, research and education in values and responsibilities.

We have planed the future academic cooperation between our research groups and Universities in the fields of mutual interest. We are looking forward to share our knowledge in the field of the semiconductor nano-system theory and publish our joint

studies' results in the field.

我注意到在基輔 Taras Shevchenko National University 國立大學的無線電物理、電子與電腦系統學院的國際合作的問題、策略與目的與國立交通大學電子工程學系有許多共同的地方，舉例來說，這個計畫的最終目標是讓烏克蘭的基輔地區變成一個有可觀的成長過程、足以支撐、有包容性的區域，必且把自己建立成國際級學術及科學參考的中心。基輔 Taras Shevchenko 國立大學提供的教育貢獻來當作一個明確的教育模範、增加有品質的研究產出、加強與公司的轉移、保持大學在代理社會變遷中的一個主動角色、去持續在有品質的科學當作一個基準點，而這個有效的經驗可以在我們的大學彼此分享。這幫助了人們實現朝向一個整體的教育，在我們的社會、環境、資源和正確的鼓勵中，透過具體的培訓來加強他們的能力與天賦，研究及教育的價值和責任。

我們計畫我們的研究團隊與大學未來在一些有共同領域興趣的進行學術合作，我們期待去分享我們在半導體奈米系統理論領域的知識及發表共同的研究的成果。

I have brought from the Taras Shevchenko National University of Kyiv much of contact information. In addition it was suggested to consider possible use of computational codes developed for appropriate simulations. Currently available simulation codes include: Numerical solver of 3D effective mass Hamiltonian, including mass dependence on position and energy (band non-parabolicity); Numerical solver of multi-band k•p Hamiltonian for valence band holes (zinc-blende and wurtzite semiconductors); Strain potential finder (based on isotropic elastic theory); State-of-the art configuration interaction codes for arbitrary number of electrons and holes; Numerical integrator of Poisson equation for inhomogeneous dielectric media; Effective mass Hamiltonian integrator including Rashba and Dresselhaus spin-orbit interaction for both electrons (linear spin-orbit int.) and holes (cubic spin-orbit int.); Relaxation rate estimator for electrons and holes subject to

spin-orbit or hyperfine interaction plus acoustic phonon coupling.

我從基輔 Taras Shevchenko National University 國立大學帶回了許多的連絡資訊。此外還有被建議可能可以在適當的模擬中使用的計算程式。目前有的模擬程式碼包含：三維有效質量的哈密頓算符，包含了質量與位置及能量的相依性（能帶非拋物線）、價帶電洞的多重能帶 k•p 哈密頓算符的數值解（閃鋅礦與纖鋅礦半導體結構）、張力位能解（基於各項等性彈性理論）、目前描述對於任意數量電子電洞的交互作用最前端的程式、對於非均勻介電質的 Poisson 方程式積分器、對於包含了 Rashba 及 Dresselhaus 自旋軌道交互作用的電子（線性自旋軌道交互作用）及電洞（立方自旋軌道交互作用）的有效質量哈密頓積分器、對於在自旋軌道或超精細交互作用加上音波聲子的電子與電動的鬆弛速率估計器