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原子能研究所

年报

INSTITUTE OF ATOMIC ENERGY ANNUAL REPORT

1980

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INSTITUTE OF ATOMIC ENERGY
(BEIJING, CHINA)

ANNUAL REPORT

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内 容 简 介

本年报全面地介绍了原子能研究所1980年（1月1日至12月31日）在核物理、核数据与核技术应用、加速器、核探测技术、计算机与计算数学、放射化学、放射化工、反应堆科学与反应堆工程、放射性同位素研制、稳定同位素分离、放射性三废处理、环境保护与辐射防护等方面研究工作的年度重要进展，重大设备的维护改进、生产运行，学术活动和国际友好往来等情况，还有该所在有关学术期刊上发表文章的目录。

本年报可供从事有关原子能科学技术研究和应用的科技人员、高等院校师生参考。

原子能研究所年报

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前　言

本期年报介绍了本所1980年度主要科学技术活动。这一年内主要进展如下。

在核物理方面　主要开展了原子核多集团的处理以及用三集团说明轻核一些性质的研究，用Skyrme力计算微观光学势的研究，以及在激子模型、深度非弹性反应和μ诱发裂变方面的研究，得到了一些颇有兴趣的结果。用夸克相互作用研究单核子及两核子间的一些性质方面继续进行了一些探索工作。在改进后的回旋加速器上，继续开展了三体反应、预平衡发射和后角反常散射等方面的实验研究工作。在研究氘核与锂-6核反应的实验中，首次得到了在^{8}Be高激发态中存在d-α-d链式分子态的实验证据，实验检验了这一反应可能存在一种新的三体反应机制——链式共振的预言。在高压倍加器上利用Ge(Li)探测器对快中子核反应在束非弹性γ射线的能谱和截面的测量得到了较精确的结果。利用^{252}Cf开展了一些裂变物理工作。

核数据评价工作方面　较系统地完成了43个核素的中子共振参数的评价。利用自己制作的群常数对一些裂变核素的评价数据开展了宏观检验。核数据评价系统的建立取得了初步进展。

核技术的应用方面　建立了堆照和加速器中子活化分析传输照射装置。利用堆中子活化分析对月球样品、国家地质标样、攀枝花铁矿中钪含量提供了重要数据。配合克山病、白血病以及一些中药的研究、配合公安部门破案做了一些工作。利用离子束分析，对半导体材料和国内外啤酒等进行了分析。在游泳池堆上开展了单晶硅中子掺杂的条件试验，并已小批量试生产，材料掺杂的合格率从常规的30%左右提高到大约80%，器件优品率有明显提高。

为了适应核物理研究的需要，继续对回旋加速器进行了改进，完成了高能区六种能量的调束。强流短脉冲电子直线模型加速器研制取得了新进展，在加工安装加速段、耦合器，更换电子枪、束流管后，完成了整体调试出束。串列加速器工程与有关部门配合已完成了施工设计、靶室设计和一系列必要的准备工作。

为开展惯性约束核聚变研究研制的相对论电子束强流脉冲加速器经过两年工作，已按原计划初步建成，总调出束。

核探测技术方面　高纯锗探测器、大体积同轴锗（锂）探测器和小平面锗（锂）探测器的研制有了新的进展。自制的硅（锂）探测器对^{55}Fe的5.9keV γ射线能量分辨率达到220eV。X射线正比管测含沙量计已进入样机试制阶段。为生物物理研究所成功地研制了用于胰岛素分子结构测量的$300\times300mm^2$和$150\times150mm^2$的二维成象多丝室。在核电子仪器方面完成了CAMAC标准插件100Mc双路定标器、束流积分仪、快速4096道ADC、FH_4-051高压电源等的研制，技术性能都比较好。

计算数学和计算机运行方面　继续开展了蒙特卡罗方法及其应用、中子迁移方程、反应堆计算方法、数据分析处理、核物理理论计算等研究工作，建立了各种程序。国产

TQ-6 计算机的运行维护水平有了进一步提高，发现并改正了机器本身的一些逻辑错误；SCORPIO-3000 计算机系统已投入使用，全年运行达 6900 小时。

放射化学方面 继续对轻水堆核燃料后处理工艺进行了研究，其中包括冷、热元件的溶解试验、普雷克斯流程中钚纯化循环的研究，对有机溶剂的辐解性质的研究和后处理过程中裂片元素化学行为研究，取得了一定的进展。新开展了双官能团有机萃取剂的应用研究，取得了初步成果。对一个 ^{252}Cf 中子源进行了化学处理。进行了14.9和5MeV中子诱发 ^{238}U 裂变产额的测定。在铀(Ⅵ)冠醚络合物的硝酸和盐酸体系的萃取研究方面，摸索了各种实验条件，提供了一些基本数据。

分析化学方面 为 UF_6 中 21 种杂质元素的分析，建立了等离子体光源发射光谱法、火花源质谱法、中子活化分析和分光光度法等。其中火花源质谱法测定 UF_6 中十一个微量元素，灵敏度可达到 1ppm 以下。中子活化分析采用高压离子交换法测定希土元素钆，探测限达到了 3×10^{-10} 克。用原子吸收分光光度法测定了 ^{6}Li 同位素丰度，精度达 0.3%，已进行了现场考验。

放射性三废处理方面 今年试验成功了一种测定高放废液玻璃固化煅烧罐料液液位的方法。完成了填充床电渗析处理低放废水的扩大试验。继续对自行研制的远距离自控无触点脱接式电动调节阀进行模拟考验。新开展了用钛酸盐类吸附剂清除废液中超钚元素的研究；用液膜分离技术去除废水中的铬，在制备乳浊液及其稳定性研究方面取得了较好结果。成功地利用铁氧体-磁滤技术清除了废水中的汞，达到了国家规定的标准。

放射性同位素研制与生产方面 一九八〇年研制和生产同位素 175 种，51027 件，强度达11019居里，供全国 1000 多家用户使用。其中用加速器试生产了25微居的 ^{208}Po，解决了 ^{99}Mo-^{99m}Tc 和 ^{113}Sn-^{113m}In 两条母牛的装柱技术；完成了九个标记化合物药箱的试制工作。为适应工业上消除静电的需要，研制了 ^{210}Po α 放射源，已在不少单位考验，效果是明显的。在放射性有机标记化合物方面，除研制了 ^{3}H，^{14}C 和 ^{125}I 等标记化合物 20 余种外，对一些新标记方法如激光标记法等进行了探索。还成功地研制了 ^{125}I，^{147}Pm，^{46}Sc三种放射性标准溶液，总不确定度在 2% 以内。

稳定同位素的分离与分析方面 新分离了 ^{84}Sr，^{119}Sn 和 ^{167}Er 三种同位素。一九八〇年除将生产的 23 种元素的 51 种同位素销售给国内有关部门外，还向国外科研机构提供了少量样品。在质谱分析方面利用新引进的 MAT-260 质谱计进行了低丰度 ^{233}U 同位素的质谱测量。

反应堆方面 完成了研究性重水反应堆的改建工作，上半年进行了各系统的安装和试车，于 6 月 27 日达到临界，12 月初满负荷运行。改建后比功率提高 50%，最大热中子通量由 1.2×10^{14}中子/厘米^2·秒增加到 2.8×10^{14} 中子/厘米^2·秒，堆辐照空间增加 2.6 倍，各项参数达到了设计指标，为堆的扩大综合利用创造了条件。游泳池堆高功率运行185天，低功率运行28天。除进行元件、材料考验外，承担了放射性同位素生产任务，前后还辐照了 100 多公斤不同厂家的单晶硅中子掺杂样品。我国在四川省建造的高通量工程试验堆(HFTR)已经建成，原 194 所有关室曾为此进行了一系列堆物理和堆工程研究、设计工作，在这期年报中刊登了这方面的部份工作。此外、在堆物理、热工水力、材料辐照效应和腐蚀性能等方面开展了若干较新课题的研究。

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辐射防护方面 在常规监测的同时，加强了管理和科研。在研究性重水堆大修改建过程中虽然遇到大剂量操作，个人剂量没有超过最大容许剂量标准。还积累了比较系统的防护资料，写出了重水堆辐射防护评价报告。提出了个人剂量二十年评价等研究报告，对医学工作在辐射防护中的地位和作用提出了看法。

一九八〇年我所学术活动活跃，组织全所性学术报告会、参加全国性学术会议和国际学术会议达78次，共提出学术报告305篇。全年发表了163篇论文报告。此外，与国外朋友的学术交往日益增多。外宾来所参观、讲学以及共同工作的有184人，作学术报告36次。我所还多次派出科技人员出国考察、参加国际专业性学术会议、从事科研工作和业务进修等，友好往来有力地增强了与世界各国科学家之间的友谊，促进了我所科技工作和干部的培养。

欢迎对本年报的缺点错误，提出批评指正。

编 者

Preface

This annual report is a summary of important scientific and technical results achieved at the Institute of Atomic Energy (IAE) in 1980. The main progress is as follows.

Nuclear Physics Some quite interesting theoretical results were obtained in the approach of multi-cluster and the illustration of the nature of light nuclei by means of three-cluster model, in the calculation of microscopic optical potential by using Skyrme force, as well as in the study of exciton model, deep inelastic collision and μ-induced fission. Further explorations were made for explaining the behaviour of nucleon spectra and nucleon-nucleon interaction in the light of quark-quark interaction. At the improved cyclotron, experiments for studying three body reaction, pre-equilibrium emission and anormalous large angle scattering were continued. In studying the reaction of deuteron on ^{6}Li nuclei, evidence for a chain-like molecular state, d-α-d, in the high-lying level of ^{8}Be was obtained for the first time and theoretical prediction on the possible existence of a new kind of reaction mechanism——chain resonance was examined experimentally. At the Cockcroft-Walton accelerator, quite accurate results of the fast neutron induced in-beam inelastic γ-ray spectra and its cross-section were measured by using Ge(Li) detectors. By the use of ^{252}Cf, some nuclear fission studies were

initiated.

Nuclear Data Evaluation The neutron resonance parameters of 43 kinds of nuclides were systematically evaluated. By using the group constants calculated in our institute, the macroscopic examination of the evaluated data for some fission nuclides was made. Moreover, initial progress was achieved in nuclear data evaluation system.

Application of Nuclear Technique Some irradiation and transfer equipments for neutron activation analysis were constructed at the reactor and accelerators, respectively. In the case of reactor neutron activation analysis, some important results about the lunar rock specimens, national geological standard specimens and the scandium content in the iron ore at Pan Zhi Hua were obtained. In the study of Keshan disease, Leukaemia, some traditional chinese medicines as well as in solving cases for assisting public security departments, neutron activation analysis played an important supporting role. Ion beam analysis was used successfully in the analysis of semiconductor materials, a variety of beers at home and abroad, etc.. The irradiation condition for neutron transmutation doping on silicon single crystals was studied at swimming-pool reactor and small batches of trial-production were carried out. The percentage of defectiveness for material doping was reduced from 70% for ordinary doping to around 20%. The percentage of high-grade electronic devices was raised significantly, too.

In order to meet the requirements of nuclear physics research, the cyclotron was further improved and the beam current extraction at six values of energy in the higher energy region was performed. New progress in the development of a prototype high-current and short-pulse electron LINAC has been made. Apart from the preparation and assembling of acceleration section and coupler as well as the replacement of electron gun and beam pipe, the adjustment of the LINAC as a whole was completed and the beam current was extracted. Under the cooperation of some related departments, the construction programme for the tandem accelerator building, the design of scattering chamber and a series of necessary preparations were finished.

After two-year efforts, a relativistic high current electron pulsed accelerator for nuclear fusion research based on inertial confinement has been preliminarily constructed and adjusted according to schedule, and the beam current has been extracted.

Nuclear Radiation Detection Technique Researches on development

of high purity Ge, large coaxial Ge(Li) and small planar Ge(Li) detectors moved forward. The energy resolution of the home-made Si(Li) detector for 5.9keV γ-ray of ^{55}Fe was improved to 220eV. The prototype of X-ray proportional counter for measuring sand content was put into trial-production. A $300 \times 300 mm^2$ and a $150 \times 150 mm^2$ two-dimensional multiwire chambers were completed successfully for determining the molecular structure of insulin at the Institute of Biophysics. As for electronic instruments, the CAMAC plug-in unit, 100MC double channel scaler, beam current integrator, 4096 channel fast ADC, FH4-051 high voltage power supply etc. were developed with good technical features.

Computation Mathematics and Computer Operation The studies of Monte-Carlo method and its applications, neutron transport equation, calculation method for reactor design, data processing and theoretical calculation of nuclear physics were continued and a variety of programmes were established. The level of operation and maintenance of a home-made computer TQ-6 was raised further and some logical mistakes of the machine were found and corrected. A computerized data acquisition and processing system SCORPIO-3000 was put into operation, and the operating time of the whole year was as long as 6900 hours.

Radiochemistry Researches on the reprocessing technology of nuclear fuel of light water reactors, including the dissolution of cold and hot fuel elements, the cycle of plutonium purification in Purex process, radiolysis property of organic solvents and chemical behaviour of fission fragment elements in reprocessing has been continued and some progress has been made. The application study of organic extraction agents with double functional group has met with preliminary success. A ^{252}Cf neutron source was chemically treated. The fission yield of ^{238}U induced by neutron was measured at 14.9 and 5 MeV, respectively. A series of experiments were performed for investigating the extraction of coordination compounds of uranium with crown ethers in a system composed of nitric acid and hydrochloric acid, and some interesting data were obtained.

Analytical Chemistry In order to determine 21 kinds of impurity elements in UF_6, Plasma atom emission spectrometry, spark source mass spectrometry, neutron activation analysis and spectrophotometric determination were established. The sensitivity of spark source mass spectrometry reached a level of less than 1ppm for eleven microelements in UF_6. The detecting limit of determining gadolinium, a rare-earth element, by using neutron activation analysis with high pressure ion-exchange was

3×10^{-10} grams. The isotopic abundance of ^{6}Li was determined by atomic absorption spectrophotometry, and in-site tests were carried out. The precision reached 0.3%.

Treatment of Radioactive wastes A method of measuring the liquid level in a calcination pot for the vitrification of high level wastes succeeded in 1980. The electro-osmosis with filled-bed for treating low-level radioactive waste water was tested on a large scale. A home-made, automatically remote-controlled electric regulator valve with no contact was tested by simulation. The study of removal of trans-plutonium elements from liquid wastes by the use of titanate as adsorption agent was initiated. In the study of removal of chromium from waste water by liquid membrance separation technique, and in the preparation of emulsion and investigation of its stability, good results were obtained. To meet the national standard of enviromental control, mercury in waste water was successfully removed by using ferrite-magnetic filtration technique.

Preparation and Production of Radioactive Isotopes In 1980, 175 kinds of radioisotopes were prepared and produced, and supplied to more than 1000 customers all over the country. 25 μCi ^{208}Po was trial-produced by accelerator. The technique of column-loading for ^{99}Mo-^{99m}Tc and ^{113}Sn-^{113m}In generators met with success. Nine kinds of labelled compound kits were prepared with success. In order to satisfy the requirements of eliminating the electrostatic accumulation in industry, ^{210}Po radioactive sources were prepared and tested in many institutions with obvious success. As for radioactive labelled organic compounds, in addition to the preparation of over 20 kinds of labelled compounds such as ^{3}H, ^{14}C and ^{125}I, some new labelling methods, for example, laser labelling were explored. Three kinds of radioactive standardized solutions, ^{125}I, ^{147}Pm and ^{46}Sc were prepared successfully with a total inaccuracy of less than 2%.

Separation and Analysis of Stable Isotopes The electro-magnetic separation of ^{84}Sr, ^{119}Sn and ^{167}Er isotopes were accomplished recently. In addition to the production of 51 sorts of isotopes of 23 elements sold to the departments concerned in our country, a small quantity of specimens were provided for research institutions abroad. As regards mass spectrometry, a newly imported mass spectrometer model MAT-260 has been used for determining the mass spectrum of low-abundance ^{233}U isotopes.

Reactor The reconstruction of the heavy water research reactor was completed. In the first half of the year, the assembling and test run of each system were carried out. It went critical on June 27 and

then reached full-loaded operation at the beginning of December. After reconstruction, the specific power was raised by 50%; the maximum thermal neutron flux was increased from $1.2\times10^{14}cm^{-2}sec^{-1}$ to 2.8×10^{14} $cm^{-2}sec^{-1}$; the usable in-core space for irradiation was increased by 2.6 times and various parameters reached the designed target, so the favourable conditions for extending comprehensive utilization of the reactor were created. The swimming-pool reactor operated for 185 days at high power and 28 days at low power, with which the test of fuel elements and materials as well as the production of radioactive isotopes were carried out. Moreover, over 100kg silicon single crystals of various factories were irradiated for neutron transmutation doping. Also presented in this issue is a part of the research and design work which was done by some laboratories belonged to the original 194 Institute in the field of reactor physics and reactor technology relating to the high flux test reactor (HFTR) located in Sichuan province. Besides, some relatively new researches on reactor physics, hydrothermodynamics, irradiation effects and corrosion behaviour of materials etc. were initiated.

Radiation Protection The routine work of monitoring as well as the management and scientific research were strengthened. Although there were some operations performed under the condition of large dosage, during the reconstruction of the research reactor, the personal dose was still below the maximum permissible value. Moreover, quite systematic reference materials for radiation protection were accumulated and an evaluation report on radiation protection for the heavy water reactor was completed. Some reports such as the evaluation of personal dosimetry for twenty years were made and some opinions were given on the role of medical work in radiation protection.

In 1980, our institute was quite active in academic exchange and discussion. The number of institute-sponsored symposiums, national conferences and the international conferences which some scientists of our institute attended amount to seventy eight. 305 papers were presented at these conferences. 163 papers were published in various journals. The international academic exchange also became increasingly strengthened; 184 foreign friends visited our institute. Some of them gave lectures and some of them even worked with us. 36 lectures were delivered by foreign visitors. Many scientists and technicians were sent abroad for technical visits, attending the international conferences, doing scientific researches and engaging in vocational studies. The academic exchange has greatly

strengthened the friendship between the scientists of China and the scientists of the countries all over the world, and promoted the work and the training of scientists in our institute.

Shortcomings and mistakes in this annual report are unavoidable, so suggestions and criticisms are surely welcome.

Editor

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目　录

核　物　理

加速器工程与技术

核探测技术

应用数学和计算数学，计算机、数据获取和处理系统的运行、维护和改进

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