

# 原子能科学技术

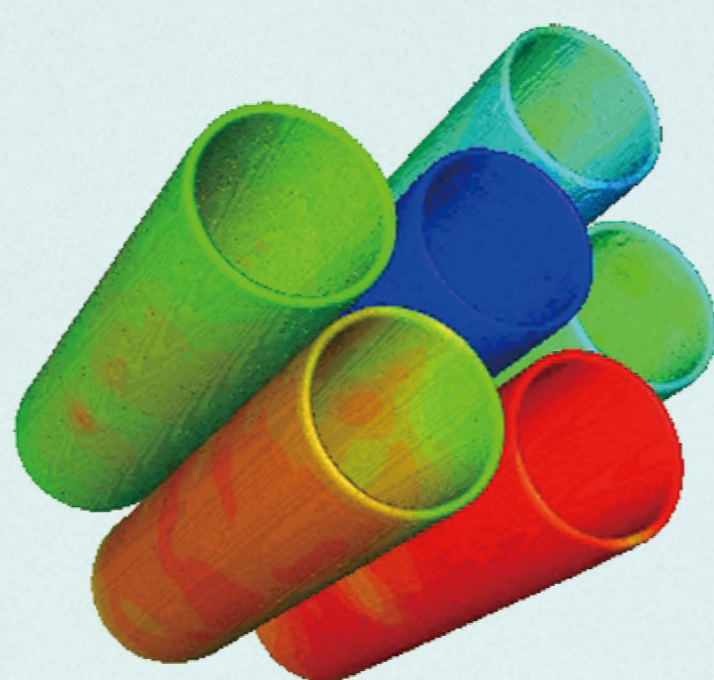
## ATOMIC ENERGY SCIENCE AND TECHNOLOGY

NO. 12 2022  
第56卷  
(卷终)

基于三维中子成像的锆合金包壳氢分布量化方法研究

武梅梅, 刘鑫, 贺林峰, 胡勇, 阮世豪,  
王天韵, 李玉庆, 魏国海, 孙凯

平均灰度值  
8800.277  
8480.424  
8160.590  
7840.747  
7520.903  
7201.060

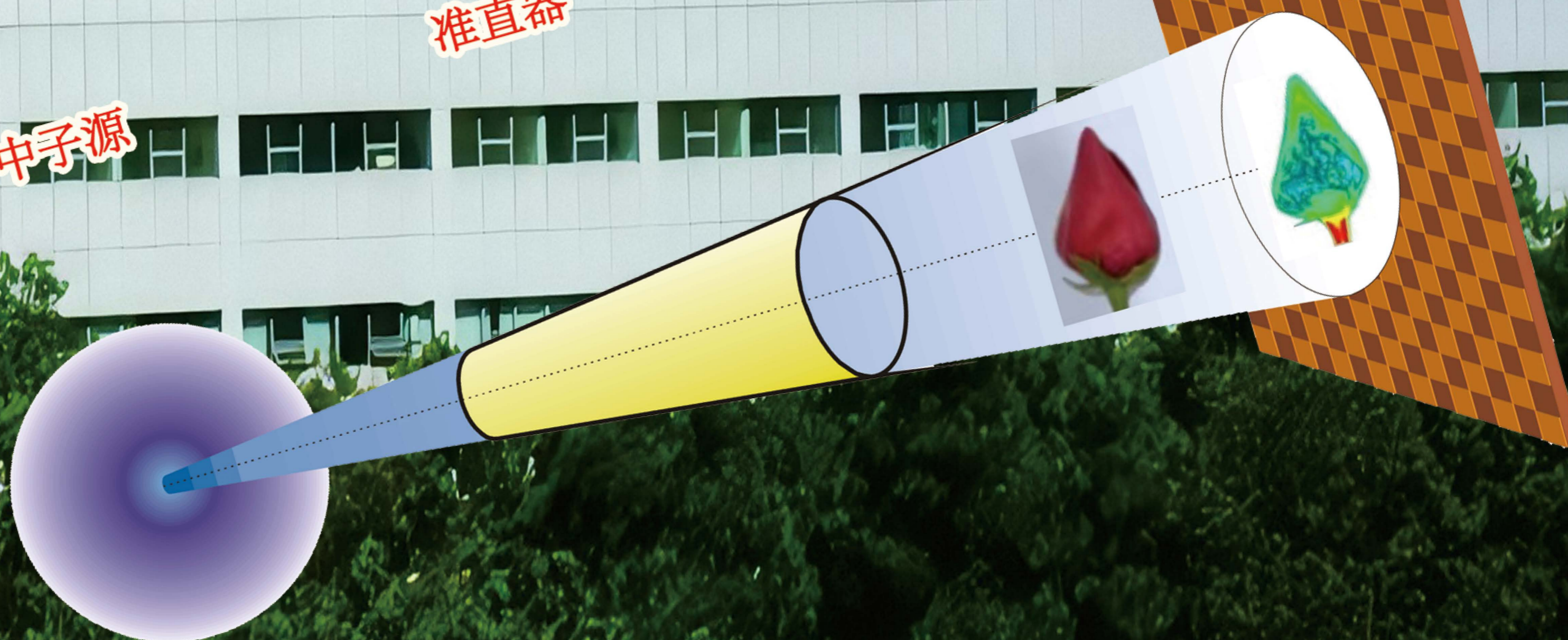


中子源

准直器

物体

探测器



ISSN 1000-6931



9 771000 693226

1.2

中国原子能科学研究院 主办  
中国核工业集团有限公司 主管

## 目 次

## 封面文章

- 基于三维中子成像的锆合金包壳氢分布量化方法研究 .....  
 ..... 武梅梅,刘 鑫,贺林峰,胡 勇,阮世豪,王天韵,李玉庆,魏国海,孙 凯(2491)

## 第十七届核技术应用学术交流会优秀论文

- pH 值对反应堆活化腐蚀产物源项影响研究 ..... 李平烈,张竞宇,杨洪新,谭 琳,赵晓泽,肖懿鑫(2498)
- 基于参数化-超单元法的 HFETR 乏燃料贮存格架抗震分析 ..... 刘金龙,章航洲,王 帅,孙志军,隆 涛(2508)
- 流动沸腾汽泡脱离频率预测模型分析 ..... 何 雯,韩晋玉,赵陈儒,薄涵亮(2517)
- 矩形窄缝通道内泡状流-弹状流流型转变准则研究 ..... 韩晋玉,何 雯,赵陈儒,薄涵亮(2524)
- C 形换热器一二次侧流动传热耦合特性数值模拟研究 ..... 褚文俊,朱宏晔,成 翔,刘 洋,段日强(2533)
- 基于 CFD 的棱柱型模块式高温气冷堆典型事故研究 ..... 黄 政,周 喆,王贺南,刘国明,陈巧艳(2543)
- 高温气冷堆耦合碘硫循环制氢的经济性研究 ..... 倪 航,曲新鹤,彭 威,赵 钢,张 平(2554)
- 高精度电容式棒位测量传感器静态特性研究 ..... 李彦霖,秦本科,薄涵亮(2564)
- 涂硼正比计数管感应电流信号模拟及脉冲宽度分析研究 ..... 朱朝阳,李立涛,邢桂来,王振涛(2573)
- 2.5 MeV 行波加速管设计 ..... 王 博,杨京鹤,杨 誉,曾自强(2581)
- 准阻抗匹配传输式的外移动式束流探测器标定装置的研发与使用 .....  
 ..... 白海涛,王 毅,何小中,廖树清,石金水(2587)
- 批量<sup>3</sup>He探测器相对探测效率标定方法研究 ..... 于嘉蕾,侯 龙,王 琦,孙 琪,朱庆福(2594)
- 常温 C<sup>4+</sup> 辐照对多晶 HIP-SiC 力学性能的影响 ..... 易柏全,刘旭东,郝祖龙(2601)
- 高放废液冷坩埚玻璃固化自适应负压调节系统的设计 ..... 王泽学,李宝军,李玉松,鄯东生(2607)

## 化学

- Re(VII)在塔木素黏土中的扩散行为 ..... 王芝芬,吴 昊,詹 玥,李 阳,花 榕,罗明标,彭道锋(2616)
- 放射性核素在饱和多孔介质原状土中运移机制研究 .....  
 ..... 陈 超,谢 添,朱 君,石云峰,李 婷,杨 松,张艾明,骆志平(2625)
- P<sub>2</sub>O<sub>5</sub>对模拟高放玻璃固化体析晶和抗浸出性能的影响 .....  
 ..... 王 宾,周杨玉铜,张壮森,姚 颖,徐立国,吴 浪(2636)

## 反应堆工程

- 高能耗下核燃料颗粒内部的应力状态及关键影响因素研究 ..... 吕俊男,杨 烁,赵 毅,李 群,龙冲生(2646)

## 万方数据

模块化小型压水堆燃料操作事故源项及剂量分析 .....	陈海英,王一川,黄旭阳,刘巧凤,李 帷,孙大威(2654)
核热推进反应堆外环境辐射场研究 .....	温永江,王成龙,张大林,秋穗正,苏光辉,田文喜(2662)
熔盐堆 <sup>135</sup> Xe和 <sup>135</sup> Xe <sup>m</sup> 迁移效应对反应性的影响 .....	吴 辰,余呈刚,蔡翔舟,陈金根(2670)
挤扭变形对低活化马氏体钢组织及蠕变性能的影响 .....	李 萍,王亚军,代记仁,田文春,薛克敏(2678)
耦合晶体取向及样品尺寸效应 A508-III 钢的室温力学本构模型构建 .....	江俊杰,金 曼,钟巍华,黎军顽,宁广胜,杨 文,翟彦荣,刘 鑫(2689)
A508-III 钢小尺寸试样的拉伸尺寸效应及其归一化模型研究 .....	忻胜民,黎军顽,钟巍华,杨万欢,宁广胜,杨 文(2698)
反应堆结构类裂纹不连续区的疲劳损伤评价方法研究 .....	庾明达,张丽屏,傅孝龙,杜 娟,邵雪娇,姜 露(2707)
超临界二氧化碳流体中纳米颗粒热泳沉积计算研究 .....	周 涛,唐剑宇,张 帆,刘文斌(2717)
铅铋冷却绕丝燃料组件横流特性分析 .....	丛腾龙,王俊杰,肖 瑶,刘茂龙,顾汉洋(2725)
基于 $k\tilde{\epsilon}-k_{\theta}-\tilde{\epsilon}_{\theta}$ 模型的液态金属三角形棒束数值传热研究 .....	苏兴康,顾 龙,李显文,张 璐,盛 鑫(2735)
基于变管径模型的高温气冷堆螺旋管式直流蒸发器两相流稳定性影响参数分析 .....	苏 阳,李晓伟,吴莘馨(2747)
空间热离子反应堆在轨保温策略及分析 .....	金 钊,王成龙,田文喜,秋穗正,苏光辉(2757)

## 技术及应用

基于能损计算的快速 $\mu$ 子吸收成像模拟研究 .....	丁文婉,刘圆圆,王 力,苏 宁,程建平,韩建武,甄 刚(2765)
C 波段 6 MeV 轴耦合驻波加速管的研制 .....	杨 誉,杨京鹤,余国龙,韩广文,吕约澎,王 博,崔爱军,吴青峰,王常强,范雨轩,朱志斌(2773)
东昆仑东段那日马拉黑南地区构造活动的磷灰石裂变径迹新证据 .....	袁二军,史立群,袁万明,金 鹏,冯子睿,田朋飞,朱传宝,丛殿阁,王延伦(2780)
《原子能科学技术》第 56 卷总目次 .....	(• 1 •)

期刊基本参数: CN 11-2044/TL \* 1959 \* m \* A4 \* 300 \* zh \* P \* ¥50.00 \* 1200 \* 34 \* 2022-12

本期责任编辑 汤晓浩 王调霞 王宝金 侯翠梅 张秀平 韩翠娥 骆淑莉

## CONTENTS

### COVER PAPER

- Study on Quantitative Method for Hydrogen Distribution in Zirconium Alloy via Neutron Tomography ..... WU Meimei, LIU Xin, HE Linfeng, HU Yong, RUAN Shihao, WANG Tianyun, LI Yuqing, WEI Guohai, SUN Kai(2491)

### EXCELLENT ARTICLES FROM THE SEVENTEEN ACADEMIC CONFERENCE ON NUCLEAR TECHNOLOGY APPLICATION

- Influence of pH on Source Term of Activated Corrosion Product in Reactor ..... LI Pinglie, ZHANG Jingyu, YANG Hongxin, TAN Lin, ZHAO Xiaoze, XIAO Yixin(2498)
- Seismic Analysis of HFETR Spent Fuel Storage Rack Based on Parameterization-superelement Method ..... LIU Jinlong, ZHANG Hangzhou, WANG Shuai, SUN Zhijun, LONG Tao(2508)
- Assessment of Predicting Model of Bubble Departure Frequency in Flow Boiling ..... HE Wen, HAN Jinyu, ZHAO Chenru, BO Hanliang(2517)
- Transition Criterion of Bubbly-slug Flow Pattern in Rectangular Narrow Channel ..... HAN Jinyu, HE Wen, ZHAO Chenru, BO Hanliang(2524)
- Numerical Simulation on Coupling Flow and Heat Transfer Characteristics of Primary and Secondary Side of C-shaped Heat Exchanger ..... CHU Wenjun, ZHU Hongye, CHEN Xiang, LIU Yang, DUAN Riqiang(2533)
- CFD-based Investigation on Typical Accident for Prismatic-type Modular High Temperature Gas-cooled Reactor ..... HUANG Zheng, ZHOU Zhe, WANG Henan, LIU Guoming, CHEN Qiaoyan(2543)
- Economic Study of High Temperature Gas-cooled Reactor Coupled with Iodine-sulfur Cycle for Hydrogen Production ..... NI Hang, QU Xinhe, PENG Wei, ZHAO Gang, ZHANG Ping(2554)
- Research on Static Characteristics of High Precision Capacitance Rod Position Measurement Sensor ..... LI Yanlin, QIN Benke, BO Hanliang(2564)
- Simulating Induced Current Signal of Boron-coating Proportional Counter and Study of Pulse Width Analysis ..... ZHU Chaoyang, LI Litao, XING Guilai, WANG Zhentao(2573)
- 2.5 MeV Traveling Wave Tube Design ..... WANG Bo, YANG Jinghe, YANG Yu, ZENG Ziqiang(2581)
- Development and Application of External Moving Type Calibration Device for Beam Detector Based on Quasi-impedance Matching Transmission ..... BAI Haitao, WANG Yi, HE Xiaozhong, LIAO Shuqing, SHI Jinshui(2587)
- Research on Calibration Method of Relative Detection Efficiency for Large Number of  $^3\text{He}$  Detector ..... YU Jialei, HOU Long, WANG Qi, SUN Qi, ZHU Qingfu(2594)
- Effect of  $\text{C}^{4+}$  Irradiation on Mechanical Property of Polycrystalline HIP-SiC at Room Temperature ..... YI Baiquan, LIU Xudong, HAO Zulong(2601)
- Design of Adaptive Negative Pressure Regulating System for Glass Solidification of HLLW by Cold Crucible ..... WANG Zexue, LI Baojun, LI Yusong, QIE Dongsheng(2607)

### CHEMISTRY

- Diffusion Behavior of  $\text{Re}(\text{VII})$  in Tamusu Clay ..... WANG Zhifen, WU Hao, ZHAN Yue, LI Yang, HUA Rong, LUO Mingbiao, PENG Daofeng(2616)

Mechanism of Radionuclide Migration on Saturated and Undisturbed Soil Medium .....  
 CHEN Chao, XIE Tian, ZHU Jun, SHI Yunfeng, LI Ting, YANG Song, ZHANG Aiming, LUO Zhiping(2625)  
 Effect of P<sub>2</sub>O<sub>5</sub> on Crystallization and Leaching Resistance of Simulated High-level Liquid Waste Glass .....  
 ..... WANG Bin, ZHOU Yangyutong, ZHANG Zhuangsen, YAO Ying, XU Liguu, WU Lang(2636)

## REACTOR ENGINEERING

Stress State and Key Influencing Factor in High Burnup Nuclear Fuel Particle .....  
 ..... LYU Junnan, YANG Shuo, ZHAO Yi, LI Qun, LONG Chongsheng(2646)  
 Analysis of Source Term and Radiation Dose in Fuel Handling Accident for Modular Small Pressurized Water  
 Reactor..... CHEN Haiying, WANG Yichuan, HUANG Xuyang, LIU Qiaofeng, LI Wei, SUN Dawei(2654)  
 Study on External Environmental Radiation of Nuclear Thermal-propulsion Reactor .....  
 ... WEN Yongjiang, WANG Chenglong, ZHANG Dalin, QIU Suizheng, SU Guanghui, TIAN Wenxi(2662)  
 Effect of <sup>135</sup>Xe and <sup>135</sup>Xe<sup>m</sup> Migration on Reactivity in Molten Salt Reactor .....  
 ..... WU Chen, YU Chenggang, CAI Xiangzhou, CHEN Jingen(2670)  
 Effect of Twist Extrusion Deformation on Microstructure and Creep Property of Low Activation Martensitic Steel .....  
 ..... LI Ping, WANG Yajun, DAI Jiren, TIAN Wenchun, XUE Kemin(2678)  
 Construction of Mechanical Constitutive Model of A508-III Steel Coupled Crystal Orientation with Size Effect at  
 Room Temperature ..... JIANG Junjie,  
 JIN Man, ZHONG Weihua, LI Junwan, NING Guangsheng, YANG Wen, ZHAI Yanrong, LIU Xin(2689)  
 Size Effect and Its Normalization Model of A508-III Steel Small Size Specimen .....  
 ... XIN Shengmin, LI Junwan, ZHONG Weihua, YANG Wanhuan, NING Guangsheng, YANG Wen(2698)  
 Fatigue Damage Assessment Method of Crack-like Discontinuous Zone in Nuclear Reactor Structure .....  
 ..... YU Mingda, ZHANG Liping, FU Xiaolong, DU Juan, SHAO Xuejiao, JIANG Lu(2707)  
 Computing Research on Nanoparticle Thermophoresis Deposition in Supercritical Carbon Dioxide Fluid .....  
 ..... ZHOU Tao, TANG Jianyu, ZHANG Fan, LIU Wenbin(2717)  
 Analysis of Transverse Flow Characteristics in LBE-cooled Wire-wrapped Fuel Assembly .....  
 ..... CONG Tenglong, WANG Junjie, XIAO Yao, LIU Maolong, GU Hanyang(2725)  
 Numerical Heat Transfer Study of Liquid Metal in Triangular Rod Bundle Based on  $k\tilde{\epsilon}\tilde{k}_\theta\tilde{\epsilon}_\theta$  Model .....  
 ..... SU Xingkang, GU Long, LI Xianwen, ZHANG Lu, SHENG Xin(2735)  
 Parameter Analysis of Two-phase Flow Stability in HTGR Helical Tube Once Through Steam Generator Based on  
 Variable Tube Diameter Model ..... SU Yang, LI Xiaowei, WU Xinxin(2747)  
 Insulation Strategy and Analysis of Space Thermionic Reactor on Orbit .....  
 ..... JIN Zhao, WANG Chenglong, TIAN Wenxi, QIU Suizheng, SU Guanghui(2757)

## TECHNIQUES AND APPLICATIONS

Fast Simulation Study of Muon Absorption Radiography Based on Energy Loss Calculation .....  
 DING Wenwan, LIU Yuanyuan, WANG Li, SU Ning, CHENG Jianping, HAN Jianwu, ZHEN Gang(2765)  
 Development of C-band 6 MeV On-axis Coupled Standing Wave Accelerating Tube .....  
 ..... YANG Yu, YANG Jinghe, YU Guolong, HAN Guangwen,  
 LYU Yuepeng, WANG Bo, CUI Aijun, WU Qingfeng, WANG Changqiang, FAN Yuxuan, ZHU Zhibin(2773)  
 New Evidence of Tectonic Event of South Narimalahei Area in Eastern Kunlun Mountain Constrained by Apatite  
 Fission Track ..... YUAN Erjun, SHI Liqun,  
 YUAN Wanming, JIN Peng, FENG Zirui, TIAN Pengfei, ZHU Chuanbao, CONG Diange, WANG Yanlun(2780)  
 Annual Cumulative Contents of Vol. 56, 2022 ..... ( • 1 • )

**Editors** TANG Xiaohao, WANG Tiaoxia, WANG Baojin, HOU Cuimei, ZHANG Xiuping, HAN Cuie, LUO Shuli