1st workshop on applications of high energy Circular Electron-Positron Collider（CEPC）synchrotron radiation source

Wednesday, December 6, 2017 - Friday, December 8, 2017

IHEP

Book of Abstracts

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PW-laser-driven directional ultra-bright gamma-rays with photon energy ranging to GeV

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The next-generation ultrahigh intensity laser pulse with the power up to 100PW will be available in the near future. To study such laser interactions with matter, We develop a QED-PIC simulation code based on our KLAPS. With the help of 2D QED-PIC simulaitons, we first investigate that next-generation laser pulses at 10–200 PW interact with a solid target in the presence of

a relativistically underdense, small-scale preplasma produced by amplified spontaneous emission (ASE). We show that QED effects can cause nearly complete energy depletion of such a pulse in the preplasma. This contrasts to the prediction by the classical laser plasma physics that the preplasma is rendered more transparent with increasing laser intensity because of laser hole boring and relativistic self-induced transparency. The QED-induced opacity therefore sets much higher contrast requirements for such a pulse in solid-target experiments than expected by classical plasma physics.

Then, we show by 3D QED-PIC simulation that as a currently-available 2.5 PW laser pulse propagates along a sub-wavelength-wide solid wire, directional synchrotron gamma-rays along the wire surface can be efficiently generated. With 8% energy conversion from the pulse, the gamma-rays contains 1012 photons between 5 and 500 MeV within 10-femtosecond duration, corresponding to peak brilliance of 1027 photons s-1 mrad-2 mm-2 per 0.1% bandwidth. Both the brilliance and photon energy are respectively 3 orders of magnitude higher than those for a typical synchrotron radiation facility. The radiation is attributed to the generation of nC, GeV electron beams well guided along the wire surface and their wiggling motion in the strong electrostatic and magnetostatic fields induced at the high-density-wire surface, where QED effects become significant. This scheme works well with the laser power ranging from 0.5 PW to 5 PW available currently.

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Si-PIN 探测器的 ASIC 读出技术研究

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在硬 X 射线调制望远镜中，有 1728 路 Si-PIN 探测器读出通道。采用了 ASIC 读出技术。有效地降低了功耗和电路规模。ASIC 是 VA32TA6 型 32 通道电荷灵敏读出芯片，内部集成了 32 路独立的前放、成型、采样保持和 ADC 模块。匹配 56mm2 的 Si-PIN 探测器，能够实现 270us 死时间，3keV@59.5keV 的能量分辨能力。本文介绍了探测器与 ASIC 的匹配方法，以及工程化的过程。

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Si-PIN、CdZnTe 和 SiC 半导体探测器的研究进展

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针对目前空间 X、γ 射线探测对辐射探测器的需求，本文将简单介绍本课题组在 Si-PIN、CdZnTe 和 SiC 半导体探测器和样机方面的研究进展。Si-PIN 探测器应用于 17 年发射的慧眼 HXMT 卫星中能 X 射线望远镜 (ME) 中，ME 共装有 432 个 MEDET 探测器，每个 MEDET 包含两个 2 像素 Si-PIN 探测器，探测能区为 5-30keV，能量分辨率为 3keV@59.5keV (-5℃)。CdZnTe 探测器应用于 X 射线时变与偏振探测卫星背景型号研制中准直型 X 射线望远镜中，能量分辨率为 4keV@59.5keV；以及引力波暴高能电磁对应体全天监测器（GECAM）的载荷伽玛射线探测器中，可实现 6 keV-2 MeV 覆盖，能量分辨率达到 <6%@662keV，计数率 2000-20000 Hz。SiC 探测器主要针对耐高温、耐辐照极端环境的需求，采用 4H-SiC 外延片制备成肖特基二极管 (SBD) α 和 γ 射线探测器，并研究其在高温和辐照环境下的性能变化，结果表明制备的探测器在 59.5KeV 的 γ 射线的能量分辨率为 9.49%，可以在 25-125℃ 条件下正常工作，经过 1Mrad 60Co γ 射线辐照后，探测器性能基本没有变化。

Summary:

针对目前空间 X、γ 射线探测对辐射探测器的需求，本文将简单介绍本课题组在 Si-PIN、CdZnTe 和 SiC 半导体探测器和样机方面的研究进展。

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Dense pair plasma generation and nonlinear QED physics with 10PW scale lasers

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With the development of ultraintense laser facilities, laser plasma interaction enters a completely new regime, where new phenomena related to nonlinear QED processes are expected to occur, such as copious γ-photon generation, electron-positron (e−e+) pair production and QED cascade, etc. Several 10PW scale laser facilities currently under construction, such as ELI and Apollo in Europe and SULF in China, will provide the possibility for experimental test of these predicted phenomena in the near future. Moreover, these ultra-high power laser facilities may allow one to study some extreme astrophysical phenomena in lab, such as relativistic e−e+ jets formation. They are ubiquitously found in black holes (BHs), pulsars and quasars, and are associated with violent emission of short-duration (milliseconds up to a few minutes) gamma-ray bursts.
We investigate the QED cascade and consequent relativistic e−e+ formation from counter-propagating laser-irradiated ultrathin foils. We present a scaling law of QED cascade growth with laser intensity, which shows that QED cascade saturation occurs at laser intensities just exceeding 10^{24} W/cm^2. QED cascade saturation results in highly efficient conversion from laser photons to e−e+ pairs with a conversion efficiency of the order of 10%. A high-yield (≥ 10^{13}) ultradense (10^{24} cm^{-3}) e−e+ bunch is produced, causing the plasma to become opaque to incident lasers. This finally leads to the emergence of a new high-field phenomenon, which is different from early discovered radiative trapping and we call it QED pair-plasma squeezing. Consequent relativistic e−e+ jet formation along the transverse direction and high-harmonic generation (HHG) along the longitudinal direction have been observed as the plasma squeezing effects become significant. The laser-driven relativistic jets formation opens up the opportunity to study energetic astrophysical phenomena in laboratory, and the HHG discovered here provides a promising way to experimentally identify these phenomena.

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Applications of Synchrotron Radiation X-ray Scattering on Interfacial Structure and Physics

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In this report, I will discuss the sciences accessible by synchrotron radiation x-ray scattering using typical science cases. Then the demands for x-ray scattering techniques from the interfacial structure and physics studies and the corresponding design of such a low-dimensional structure probe at HEPS mainly based on surface x-ray scattering technique will be presented. And the features, progress and future applications of the low-dimension structure probe will also be introduced.

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Copious electron-positron pairs generation with PW laser pulses

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Matter can be transferred into energy and the opposite transformation is also possible by use of high-power lasers. A laser pulse in plasma can convert its energy into γ-rays and then e^-e^+ pairs via the multi-photon Breit-Wheeler process. Production of dense positrons at GeV energies is very challenging since extremely high laser intensity $\sim 10^{24}$ Wcm^{-2} is required.

Here we propose an all-optical scheme for ultra-bright γ-ray emission and dense positron production with lasers at intensity of 10^{22-23} Wcm^{-2}. By irradiating two colliding elliptically-polarized lasers onto two diamondlike carbon foils, electrons in the focal region of one foil are rapidly accelerated by the laser radiation pressure and interact with the other intense laser pulse which penetrates through the second foil due to relativistically induced foil transparency. This symmetric configuration enables efficient Compton back-scattering and results in ultra-bright γ-photon emission with brightness of $\sim 10^{25}$photons/s/mm^2/mrad^2/0.1%BW at 15 MeV and intensity of 5×10^{23} Wcm^{-2}. Our first three-dimensional QED-PIC simulation shows that a GeV positron beam with density of 2.5×10^{22} cm^{-3} and flux of 1.6×10^{10}/shot is achieved. Collective effects of the pair plasma may be also triggered, offering a window on investigating laboratory astrophysics at PW laser facilities. This compact electron-positron pair source could be basis for future high luminosity e^-e^+ collider.

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Abnormal threshold anomaly in exotic nuclear systems and its significances

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The threshold anomaly of the phenomenological potential has been known for a long time in nuclear reactions at energies around the Coulomb barrier, where the connection between the real and imaginary potentials is well described by the dispersion relation. However, this connection is not clear yet for some weakly bound nuclear systems, especially for reactions induced by exotic radioactive nuclei. In this study, precise optical potentials of the halo nuclear system 6He+209Bi were extracted via 208Pb(7Li, 6He) transfer reactions with energies measured downward to the extremely sub-barrier region. The real potential presents a bell-like shape around the barrier as a normal threshold anomaly in tightly bound nuclear systems. However, the imaginary potential shows an abnormal behavior: it increases first with energy decreasing below the barrier and then falls quickly down to 0. It is the first time the threshold of the imaginary potential has been determined in an exotic nuclear system. Moreover, experimental results show the dispersion relation is not applicable for this system, which may be a common phenomenon for exotic nuclear systems. We discuss possible explanations for such a peculiar behavior, but further study is still desired for the underlying physics.

Summary:

The optical potentials of exotic nuclear systems show an abnormal threshold anomaly behavior, that may have many implications on other areas of knowledge. Finally, the applications of the dispersion relation by using the CEPC-r facility are discussed.

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Test-Beam Facility at IHEP CAS

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Introduce the Test-Beam Facility at IHEP CAS

Summary:

Test-Beam Facility is very important for detectors R&D and can be used in a lot of other applications.

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detector progress of synchrotron radiation at IHEP

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CEPC introducation

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The generation of high collimated γ-ray source for the application of photon-photon collider

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A scheme to generate highly collimated γ-ray pulse is proposed for enhancing the prodcution of electron and muon pairs in γ-γ collider. The γ-ray pulse , with high conversion efficiency, can be generated. Numerical simulation shows that 18% energy of a 10 PW laser is transfered into the forward γ-rays in a divergence angle less than 3 degree. Such γ-ray pulse can enhance the electron and muon pairs by more than 3 orders of magnitude.

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超强激光与等离子体相互作用中非线性 Compton 散射与韧致辐射

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超强激光与等离子体相互作用时会产生高能辐射甚至产生正负电子对。我们讨论了如何使用 Monte-Carlo 模拟该体系相互作用中高能伽马光子辐射与正负电子对的产生等。通过激光与等离子体相互作用的 Particle-In-Cell (PIC) 粒子模拟与蒙卡模拟的耦合我们研究了高能韧致辐射和非线性 Compton 散射。研究表明，在一定的激光强度范围内以及高 Z 等离子体中，韧致辐射对高能光子的贡献是不能忽略的。

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超强激光驱动等离子体产生稠密正负电子对的粒子模拟研究

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随着激光技术的发展和拍瓦级激光装置的建立,在实验室内有望获得聚焦强度高达 1022W/cm2 的超强激光，把激光物质相互作用推进到高度相对论和非线性的范畴，甚至出现量子电动力学效应，激发 X 射线、伽马射线和正电子等高能辐射束。我们基于含 QED 效应的开源 PIC 程序 EPOCH，对双束相向传播的激光与充有近临界密度等离子体的双锥靶的相互作用开展数值模拟，研究表明：电子在锥内的聚焦激光场中发生辐射捕获并剧烈振荡；电子运动辐射的高能伽马射线与对向传播的激光光子作用，通过 Breit-Wheeler(BW) 过程产生高能量的稠密正负电子对。这有可能为高能量密度物理、激光核物理、实验室天体物理等研究提供一种台面型的高能射线源与正电子源，具有重要的应用价值。

Summary:

对双束相向传播的激光与充有近临界密度等离子体的双锥靶的相互作用开展粒子模拟研究，发现锥内被辐射捕获的高能电子辐射出高能伽马射线，并与对向传播的激光光子作用通过 Breit-Wheeler(BW) 过程产生高能量的稠密正负电子对。这有可能为高能量密度物理、激光核物理、实

验室天体物理等研究提供一种台面型的高能射线源与正电子源。

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高能闪光照相 X 射线源能谱测量

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闪光照相光源由高能强流脉冲电子束打靶时的韧致辐射产生，具有宽谱和连续分布的特点。高能 X 射线能谱是闪光照相图像处理的重要实验参数，对提高客体材料的密度反演精度具有十分重要的意义。基于康普顿散射的 X 射线能谱测量技术，可将入射光子的能谱分布转换为康普顿反冲电子的能谱分布，然后利用磁场对电子运动的空间色散分析测量反冲电子的能谱分布，进而反推获得光子能谱分布。

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Optics design of the CEPC collider ring

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CEPC is a future Circular Electron and Positron Collider proposed by China to mainly study the Higgs boson. This report will mainly present the optics design for the collider ring as well as the synchrotron radiation related issues.

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Photodisintegration reaction measurement: a probe of p-process for nuclear astrophysics

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p-process is proposed to explain the mechanics of the synthesis of the stable neutron-deficient nuclides heavier than iron that are observed up to now in the solar system. These nuclides cannot be produced by the slow or rapid neutron captures (s- or r-process), but can be transformed from some seed nuclides formed in the s- or r-process through the photodisintegration reactions, capture reactions, and so on. To establish the feasible network calculation of the p-process, more than 2000 nuclides and 20000 reactions have to be taken into consider, wherefore Hauser-Feshbach statistical model are generally used. More experimental data of photodisintegration reactions are required for references and restrictions of the statistical model. In the presentation, main experimental measurement methods of photodisintegration reactions and also the inverse reactions are introduced. Some experimental measurement progress by Beihang group for proton induced reactions of Dy isotopes are presented as well.

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