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基于康普顿散射的硬 X 射线辐射场调制方法

Abstract

The hard X-ray produced by the bremsstrahlung from low-energy electrons has a large emit angle, which makes a low utilization ratio of the radiation field in hard X-ray source. A modulation method based on Compton scattering to increase the utilization ratio of the radiation field is presented in this paper. Escaped photons are scattered into the detection region partially to increase the utilization ratio of radiation field by a Compton scattering layer with specific materials and structures. In addition, the average energy of the photon is reduced. The progress of Compton scattering of photons in materials at different energy and incident angles is studied. The effects of the materials and structures of Compton scattering layer on the radiation intensity and photon energy of X-ray are simulated. A Compton scattering layer is designed for the hard X-ray source, the array of cylindrical virtual cathode reflex triode, and an experimental study has been carried out. The experimental results show that the utilization ratio of the radial field is increased by 12% by the Compton scattering, which is an effective method to enhance the intensity of the radiation field.

Keywords

Compton scattering, hard X-ray source, bremsstrahlung, Cylindrical Virtual Cathode Reflex Triode

关键词

康普顿散射，硬 X 射线源，轫致辐射，同轴虚阴极反射三极管

摘要

低能电子轫致辐射产生的硬 X 射线发射角度大，造成硬 X 射线源的辐射利用率低。本文介绍了一种采用康普顿散射提升硬 X 射线源辐射利用率的方法，通过设置特定材料和结构的康普顿散射层，将逃逸光子部分散射至探测区域，增大辐射利用效率；同时降低光子平均能量。研究了不同能量和入射角度下光子在材料中发生康普顿散射的过程；模拟了康普顿散射层的材料和形状对 X 射线的辐射强度和光子能量的影响。针对同轴虚阴极反射三极管阵列型硬 X 射线源，优化设计了康普顿散射层并开展实验研究。结果表明：通过康普顿散射可将辐射利用率提升 12%，是提升辐射场强度的有效方法。

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