自定义电子涡旋光束的创新研究

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传统的电子涡旋在强度模式方面存在一定的局限性，即它们通常只能呈现出各向同性的圆环形强度模式。这种模式的形成与电子束的恒定相位梯度分布有关，它无法提供更多样化的电子束形状，从而限制了电子涡旋在更广泛应用中的潜力。

南京大学徐挺教授和陆延青教授团队基于电子束局部发散角与方位角相位梯度之间的关系，创造出具有非同质强度分布的结构化电子涡旋。这一突破意味着电子涡旋的强度模式可以根据特定的需求进行定制，为电子束的操控和应用开辟了新的维度。研究团队展示了如何通过计算机生成的全息图和设计相位掩模在透射电子显微镜中调节入射的自由电子，以产生具有不同强度模式的结构化电子涡旋。

该研究不仅在理论上拓宽了对电子涡旋的理解，而且在实验上展示了通过操纵电子束的局部结构来控制其强度模式的可行性。这种新型的结构化电子涡旋作为量子电子探针，对电子显微学和纳米技术等领域的未来应用具有重大潜力。提出的概念和生成方法不仅限于电子，还可以推广到其他粒子系统，如中子、质子、原子和分子。这为粒子束的进一步研究和应用提供了新的视角和方法。

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A new chapter in quantum vortices: customizing electron vortex beams

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The research group of Prof. Ting Xu and Prof. Yanqing Lu from Nanjing University have created structured electron vortices with non-homogeneous intensity distributions based on the relationship between the local divergence angle and azimuthal phase gradient of electron beams. This breakthrough means that the intensity patterns of electron vortices can be customized according to specific needs, opening new dimensions for the manipulation and application of electron beams.

This study not only broadens the theoretical understanding of electron vortices but also demonstrates experimentally the feasibility of controlling their intensity modes by manipulating the local structure of the electron beam. Thanks to its additional controllable degree of freedom, the structured electron vortices as a quantum electron probe holds great potential in electron microscopy and can further promote various in-situ applications, such as electron manipulation of nanoparticles along designed trajectories, pattern-dependent interaction of electron orbital angular momentum with matter, and selectively exciting and probing surface plasmon modes. The structured electron vortices also can be directly used in lithography to produce shaped nanostructures without the need to scan the beam.

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