基于全介质非线性超表面的二次与三次谐波产生的增强与调控技术

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超表面为非线性光学的研究提供了一个有发展前景的平台，但是目前大多数的非线性超表面仅专注于单一的倍频转换，且缺乏高效调控非线性光学响应的手段。另一方面，实现局域场增强的物理机制也是获得有效频率转换的关键因素。

伦敦大学学院的 Nicolae C. Panoiu 教授团队、澳大利亚国立大学 Yuri Kivshar 教授团队及哈尔滨工业大学（深圳）宋清海教授团队联合报道了一种基于导模谐振和连续域束缚态的全介质非线性超表面，实现了二阶和三阶非线性光学响应的共振增强。在该项工作中，研究团队借助了导模谐振和连续域束缚态的丰富物理特性来实现高 Q 谐振。通过打破由中心对称非晶体硅构成的超表面的单元结构对称性，连续域束缚态转变为准束缚态，从而使得连续域束缚态与连续光谱之间的耦合变得可能。在此条件下，基频谐振引发的光与物质的高强度相互作用，导致了二倍频和三倍频处的非线性极化增强，从而增强了二次和三次谐波的产生及发射。

为了更深入地了解所研究的非线性光学过程，研究团队通过数值计算进一步研究了非线性发射与超表面单元结构不对称性之间的关系，并揭示了基于线性导模谐振和连续域束缚态的谐波信号对超表面不对称的高度依赖性。

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Enhancement and manipulation of second- and third-harmonic generation based on all-dielectric nonlinear metasurfaces

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Metasurfaces provide a promising platform for the study of nonlinear optics. However, most proposed nonlinear metasurfaces only focused on a single frequency conversion process and lack an efficient way to control and adjust the intensity of the nonlinear optical interactions. On the other hand, the physical mechanism to achieve local field enhancement is also a key factor in achieving effective frequency conversion.

The research group of Prof. Nicolae C. Panoiu from University College London reported on an all-dielectric nonlinear metasurface for giant enhancement of second-order and third-order nonlinear optical response, induced by guided mode resonance and bound states in the continuum. In particular, the researchers took advantage of the rich physics of optical guided mode resonances and bound states in the continuum to generate high-Q resonant spectral features. To this end, by breaking the structural symmetry of a metasurface composed of centrosymmetric amorphous silicon, bound states in the continuum are transformed into quasi bound states in the continuum, thus allowing the coupling between these resonant states and the radiative continuum. Under these conditions, the high-intensity light-matter interaction caused by existence of resonances at the fundamental frequency give rise to enhanced nonlinear optical polarization at the second- and third-harmonic, which produces enhanced second- and third-harmonic optical beams emitted from the amorphous silicon resonators.

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