Tailoring 3D Star-Shaped Auxetic Structures for Enhanced Mechanical Performance	
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Abstract: Auxetic lattice structures are three-dimensionally designed intricately repeating units with multifunctionality in three-dimensional space, especially with the emergence of additive manufacturing (AM) technologies. In aerospace applications, these structures have potential for use in high-performance lightweight components, contributing to enhanced efficiency. This paper investigates the design, numerical simulation, manufacturing, and testing of three-dimensional (3D) star-shaped lattice structures with tailored mechanical properties. Finite element analysis (FEA) was employed to examine the effect of a lattice unit's vertex angle and strut diameter on the lattice structure's Poisson's ratio and effective elastic modulus. The strut diameter was altered from 0.2 to 1 mm, while the star-shaped vertex angle was adjusted from 15 to 90 degrees. Laser powder bed fusion (LPBF), an AM technique, was employed to experimentally fabricate 3D star-shaped honeycomb structures made of Ti6Al4V alloy, which were then subjected to compression testing to verify the modelling results. The effective elastic modulus was shown to decrease when increasing the vertex angle or decreasing the strut diameter, while the Poisson's ratio had a complex behaviour depending on the geometrical characteristics of the structure. By tailoring the unit vertex angle and strut diameter, the printed structures exhibited negative, zero, and positive Poisson's ratios, making them applicable across a wide range of aerospace components such as impact absorption systems, aircraft wings, fuselage sections, landing gear, and engine mounts. This optimization will support the growing demand for lightweight structures across the aerospace sector.