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Beam lattice metamaterials with internal contact and instabilities

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Flexible and soft mechanical metamaterials with artificially designed microstructures have attracted attention due to their unusual and tunable properties with applications in, e.g., soft robotics and energy harvesting. Moreover, the interest in such materials has been increased hand in hand with the progress in additive manufacturing, enabling the fabrication of the designed microstructures.

The classical mechanical metamaterials include, e.g., auxetic (negative Poisson's ratio) metamaterials, metamaterials with vanishing shear modulus, and topological metamaterials. Another exciting group of metamaterials consists of the so-called programmable materials whose properties can be switched by external stimuli. To achieve such a behavior, we propose an architected hexagonal lattice with an additional internal contact mechanism. Careful design and rearrangement of the underlying contact mechanism lead to tunable stiffness, which can be adapted to a specific application.

The design of the proposed metamaterial relies upon a robust and efficient computational tool. The development of such a tool is challenging mainly due to the internal contact and large deformations of the lattice with a possibility to develop instabilities. Therefore, the adopted computational method is based on the recently proposed geometrically exact beam element [1]. Moreover, the element formulation is extended to incorporate the contact internally, leading to a very efficient formulation.

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REFERENCES

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