A ribbon model for nematic polymer networks

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Abstract

Nematic polymer networks (NPNs) are rubber-like materials with nematogenic molecules embedded in the constituent polymer chains of the material. These materials can be deformed reversibly by the action of heat/light on the material from a distance, without any material contact with the source of heat/light. This key property of NPNs can be exploited for a wide variety of applications in industry, such as soft actuators, strain sensors, etc. In this talk, I will discuss a theory of deformation of ribbons cut out from a thin NPN sheet. The theory describes the natural and deformed configurations of an NPN ribbon as ruled surfaces, connected by a deformation map that allows for stretching that involves the imprinted nematic director field (an idealisation of the average orientation of the nematogenic molecules embedded in the polymer matrix). The main result of the theory is an energy density for NPN ribbons, obtained by a dimension reduction of a surface energy density of a thin NPN sheet. Thereafter, I will discuss planar as well as three dimensional numerical solutions of the developed theory, and present computations that provide us with an estimate of the efficiency with which NPN ribbons convert heat into mechanical work.

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