Anisotropic bijels for radiative cooling

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The cooling of buildings requires an enormous amount of energy, and due to a warming climate the cooling needs will increase over the coming decades [1]. Passive radiative cooling of a building could be achieved by optimizing the optical properties of the walls and roof. Indeed, if a surface radiates more energy (by way of infrared radiation) than that it absorbs energy from solar irradiation, the surface will cool down [2].

One highly reflective surface found in nature is the chitin shield of the white scarab beetle [3]. The high reflectance of the beetle shield has been shown to be a result of the optimized degree of anisotropy in the interwoven structure of the chitin filaments. This observation has been confirmed by computational studies and shown to be invariant of the exact topology of the structure [4].

In our group a different interwoven structure is extensively studied. The structure that forms during spinodal phase decomposition can be kinetically trapped through the absorption of nanoparticles to the interface, forming a bicontinuous interfacially jammed emulsion gel (bijel) [5, 6]. Crucially, while the structures are typically isotropic, recently the typical domain size has been tuned to several hundreds of nanometers [7]. As a result, the material has a correlation length similar to the wavelength of visible light.

In this project we attempt to find experimental confirmation of the influence anisotropy has on the reflectance, with the aim of producing a passively cooling surface. To do so we will make anistropic bijel structures which have correlations on the length scale of visible light wavelengths. To achieve this, we consider two general strategies, either post-processing the structure by stretching, or influencing the spinodal decomposition dynamics by using high aspect ratio nanoparticles in the synthesis process. By combining these methods we aim to control the domain shapes, and by extension degree of anisotropy, of the bijels. We then characterize both the structure and optical response of these bijels, thus allowing us to correlate the correlation lengths and anisotropy of the structure to the total reflectance.

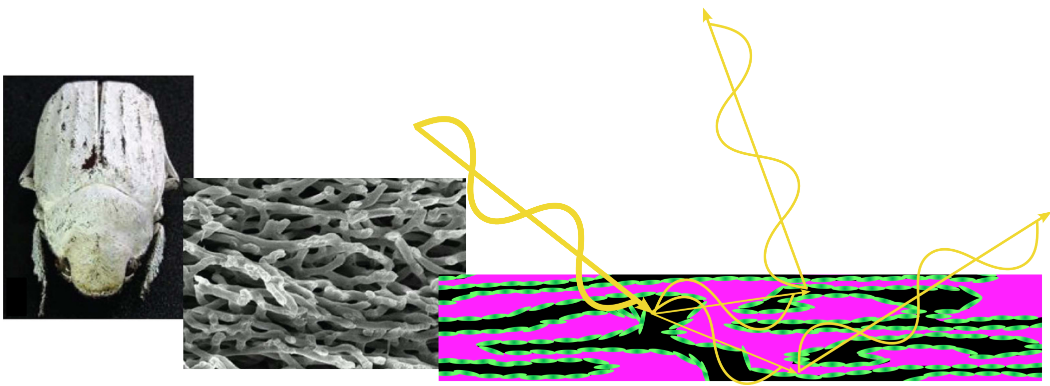

Figure 1: Project inspiration. From left to right, the white scarab beetle, a scanning electron micrograph from its shield and an anisotropic bijel reflecting light. The electron micrograph shows the unordered and anisotropic structure of the chitin filaments. This structure is similar to the stretched bijel structure shown on the right. The light scatters multiple times in the structure, such that a small refractive index mismatch is sufficient to achieve high reflectance. White scarab beetle picture and micrograph reproduced from [3].

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