The secret to improving liquid crystal's mechanical performance

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By deliberately interrupting the order of materials - by introducing different atoms in metal or nanoparticles in liquid crystals - we can induce new qualities. For example, metallic alloys like duralumin, which is composed of 95% of aluminium and 5% copper, are usually harder than the pure metals. This is due to an elastic interaction between the defects of the crystal, called dislocations, and the solute atoms, which form what are referred to as Cottrell clouds around them. In such clouds, the concentration of solute atoms is higher than the mean concentration in the material.

In a paper published in *EPJ E*, Patrick Oswald from the École Normale Supérieure of Lyon, France, and Lubor Lejček from the Czech Academy of Sciences have now theoretically calculated the static and dynamical properties of the Cottrell clouds, which form around edge dislocations in lamellar liquid crystals of the smectic A variety decorated with nanoparticles. This work could be important, for example, in the context of improving the lubricating performance of such liquid crystals.

The Cottrell clouds are difficult to study in solid materials, and even more so when the dislocations are in motion. This is not the case in a smectic A liquid crystals doped with gold nanoparticles where the Cottrell clouds are visible under a simple optical microscope. In addition, the density of dislocations can be controlled experimentally in these materials, allowing the dislocation mobility to be directly measured. A recent experiment showed that it decreases as the concentration of nanonoparticles increases. This leads to a hardening of the material, very similar to what is observed in metallic alloys.

When the dislocations move slowly, the Cottrell clouds of nanoparticles are dragged by the dislocations, which decreases their mobility. In this study, the authors demonstrate a formula previously used to approximate the mobility of dislocations in the presence of Cottrell clouds. They then perform a numerical simulation of the problem to study how the Cottrell cloud erodes when the dislocation moves at high speed.

More information: P. Oswald et al, Drag of a Cottrell atmosphere by an edge dislocation in a smectic-A liquid crystal, *The European Physical Journal E* (2017). DOI: 10.1140/epje/i2017-11573-9

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