	Experiment title: Biaxiality in Nematic Suspensions of Colloidal Goethite	**Experiment number**: 26-02-581
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Report: (max. 2 pages)

Dispersions of boardlike goethite (α-FeOOH particles with rectangular cross sections) display very rich phase behaviour [1-3]. Moreover, goethite particles show interesting magnetic properties. They possess a permanent magnetic moment along their long axis combined with an induced moment with an easy axis along the shortest particle dimension. This combination leads to peculiar re-orientation phenomena as the strength of the external magnetic field varies.

First, we focused on the nematic phases, where particles align their long axes but do not have long-range positional order. In a previous experiment at DUBBLE, we found the first example of a "simple" biaxial nematic (as well as a biaxial smectic) phase in a lyotropic mineral liquid crystal of boardlike goethite particles (with rectangular cross section a x b and length c) [3]. The experimental system in which the biaxial nematic was found, possessed dimensions close to the point $a / b = b / c$ (when particles are on the limit between prolate and oblate). Surprisingly, we did not find a uniaxial nematic phase is this particular system. Recent theoretical work shows that an interplay between sedimentation and fractionation (related to our experimental polydispersity of 25%) could lead to a strongly reduced but still observable range of uniaxiality [4]. During these experiments we studied this in more detail. To do this, we performed a detailed scan of the capillary while applying a small magnetic field along the direction of the X-ray beam.

At the moment, it is hard to conclude if in old capillaries (made in 2005) a uniaxial nematic phase present is in between the biaxial nematic and isotropic phase. We need to continue with a detailed analysis of the data collected to check if some of the patterns are uniaxial nematic or isotropic. A fresh capillary of the same system (3 months old) clearly shows a uniaxial nematic phase in between the biaxial nematic and the isotropic phase. This implies that the system does form a uniaxial and biaxial nematic phase but that the stability of these phases is a function of time. We plan to enlighten the subject in the further studies. (Capillaries are always kept in a vertical position so that a sedimentation equilibrium profile develops.)

We also studied the same system in a larger magnetic field (now perpendicular to the X-ray beam), where the particles rotate from parallel to perpendicular to the field. Several interesting observations were made during this rotation process, one of which we will discuss here.

Normally, the columnar phase of goethite is centered rectangular and gives 2 sharp scattering rings from the (11) and (20) reflections (Fig. 1a, corresponding to the red and gray periodicities respectively in Fig. 2a). When we applied a magnetic field above the critical field, first the (11) ring became broader (Fig. 1b). In even higher fields, the ring turned into arcs (Fig. 1c), which do not fall on a circle. When using longer exposure times the (02) peaks became visible (purple in Fig. 2), which turned out to be spread along an arc as well (Fig. 1d).

We think that 2 effects play a role: domain orientation and sliding of the columns. Without distortion there will be scattering peaks at an angle corresponding to the distance of the gray (20), purple (02) and red (11) periodicities (Fig 2a). If a domain is rotated a bit, all peaks will change a bit their orientation. However, if it is accompanied with a slide of columns, as depicted in Fig 2b, the scattering angles of some of the peaks will change as well. The red periodicities now become the green and blue ones and also the purple periodicity changes a little. A schematic picture of the changes in the scattering pattern is shown in Fig. 2c.

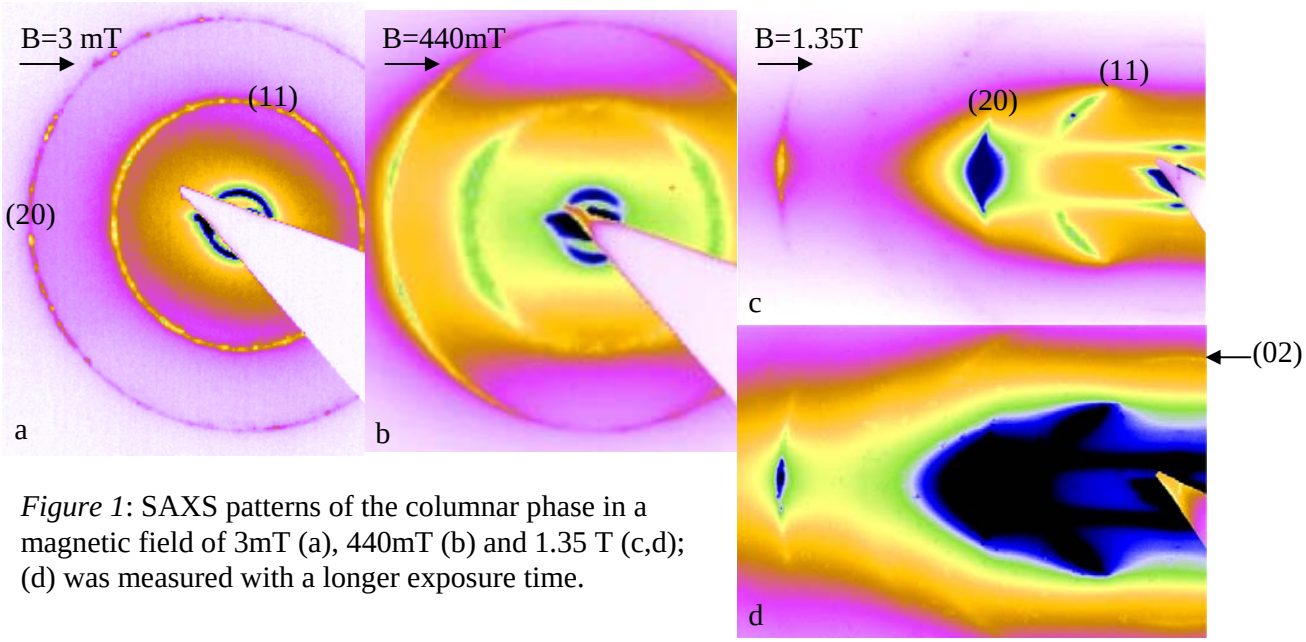

Figure 1: SAXS patterns of the columnar phase in a magnetic field of 3mT (a), 440mT (b) and 1.35 T (c,d); (d) was measured with a longer exposure time.

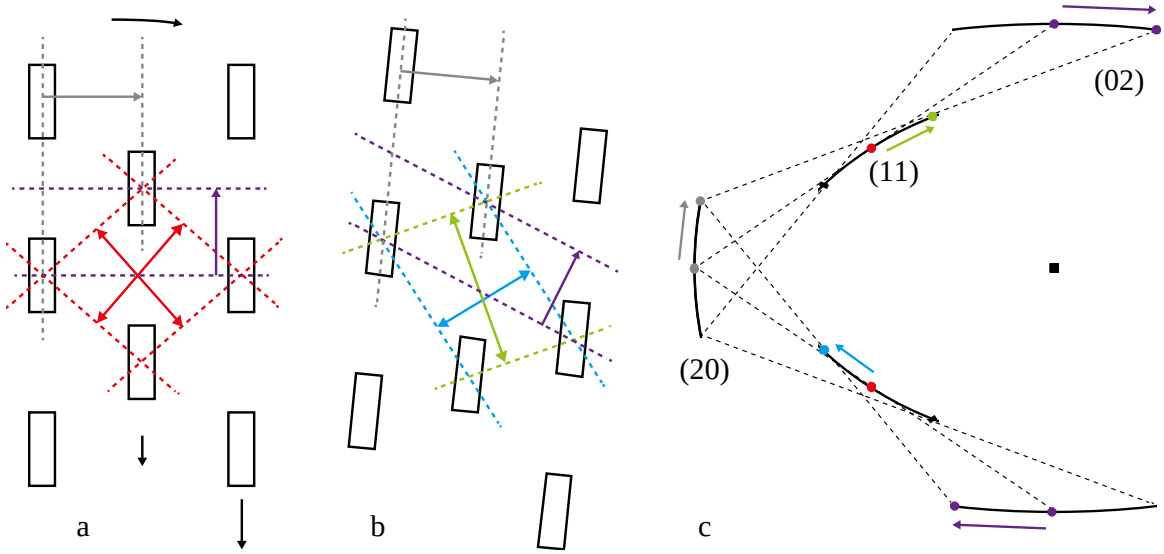

Figure 2: The columnar phase of goethite, (a) the well aligned structure and (b) with distortions. (c) Shows a schematic picture of the peak shift.

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