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Experiment Report Form

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- fill in a separate form for each project or series of measurements.
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- include the reference number of the proposal to which the report refers.
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- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

(next page)

	Experiment title: Aligning liquid-crystalline anisotropic colloids in high magnetic field	**Experiment number:** **26-02-133**
Beamline: BM-26B	**Date(s) of experiment:** From: 04-11-2002 To: 08-11-2002	**Date of report:** 18 - 12 - 2002
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In our experiments, we have used sterically stabilised gibbsite (γ-$Al(OH)_3$) platelets in organic solvent. Dispersions of this kind of particles display the isotropic (I) and liquid crystalline nematic (N) phase, due to their shape anisotropy (diameter = 200 ± 30 nm, thickness = 13 ± 4 nm). Preliminary experiments at our laboratory have shown that the platelets align in a magnetic field. This field-dependent alignment was investigated in detail at the SAXS station of the DUBBLE beamline using high magnetic field.
It is important to note that in our system, the platelets orient in such a way that the platelet normal $\boldsymbol{n}$ is perpendicular to the magnetic field $\boldsymbol{B}$. This means that the particles still have one rotational degree of freedom, with $\boldsymbol{n}$ in the plane perpendicular to $\boldsymbol{B}$. In the geometry of our experiment, the anisotropy in the SAXS pattern mostly originates from a few of all orientations with $\boldsymbol{n} \perp \boldsymbol{B}$. In the experiments on the nematic phase, we will remove the degeneracy by rotating the sample in the field.
Various isotropic and nematic samples were prepared in cylindrical glass capillaries with a diameter of 0.7 mm and 1.0 mm. At magnetic field strengths that varied from 0 to 7 T, scattering patterns were obtained using a gas-filled detector at a distance of 8.5 metres from the sample. Photon energy was 17 keV (λ=0.073 nm), resulting in an accessible q range of about 0.03 to 0.8 nm^{-1}.
In the first series of measurements (using isotropic samples at volume fractions of ϕ=5.0%, 10.9%, 16.5% and 21.9%) we observed alignment of the platelets due to the field. At the lowest concentrations, the alignment was observed only at high magnetic field strengths (> 5 T). At a volume fraction of 16.5%, the effect was measurable, though not very strong. At 21.9% (the isotropic co-existence concentration), the effect was remarkable, see figure 1. Unfortunately, the

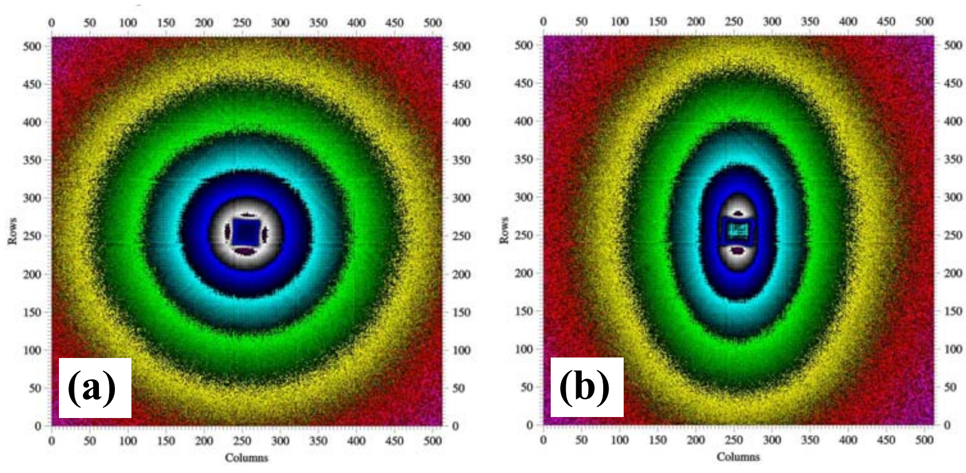

Figure 1 - The co-existing isotropic phase at (a) B=0 T and (b) B=7 T.

superconducting magnet quenched during the ϕ=5% run. Therefore, we were not able to complete the measurements at ϕ=5.0% and lower, nor at ϕ=19.8%. In particular, this last series is very important and it is necessary to complete it in the future.

The second series comprised measurements of the nematic samples. Optical observations between crossed polarisers (but also the SAXS experiments) showed that the nematic samples were aligned already in some preferred direction. This is very likely due to the filling of the capillaries. In order to rule out these artefacts, the nematic samples were permanently rotated in the magnetic field at a constant speed of 1.7 rpm to induce one specific (non-degenerate) orientation, thus creating a mono domain. SAXS measurements were performed on the nematic phase at ϕ=27.2%, 30.4% and 34.8% using a small permanent magnet with the maximum field of B=1.2 T. Figure 2a through 2d depict the ϕ=27.2% sample under various conditions of field and rotation. Without magnetic field, the samples showed anisotropic scattering patterns with slight preference for a horizontal orientation (indicating that the platelets are vertical), see figure 2a. After applying a small magnetic field (~0.3 T) the anisotropic pattern had rotated over 90° (indicating that the platelets are preferably oriented along the horizontal magnetic field), see the example in figure 2b. After starting the rotating stage, the patterns fluctuated for about 30 seconds, became anisotropic again (vertical pattern) and reached maximum anisotropy after 1 to 2 minutes, as depicted in figure 2c. The (final) anisotropy

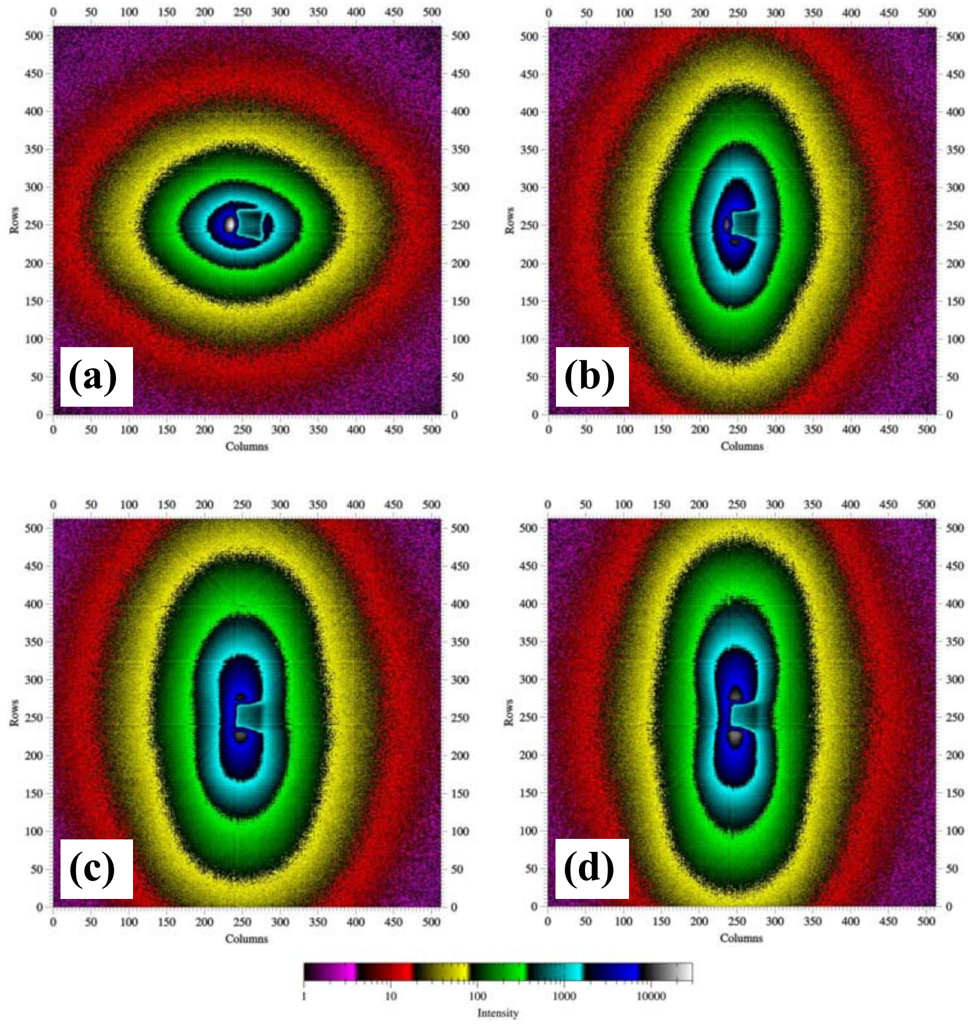

Figure 2 - A nematic sample (ϕ=27.2%) that was subjected to (a) no field, (b) a small magnetic field (~0.3 T), (c) sample rotation at this small field and (d) sample rotation at a field strength of about 1.2 T, subsequently. The magnetic field was directed horizontally.

increases with increasing volume fraction and increasing magnetic field (compare figure 2c and 2d), thus indicating an increase of the orientational order parameter. At ϕ=30.4%, an effect of the structure factor could be seen, indicative of the thickness-related typical interparticle distances. (Previous experiments at DUBBLE on a nematic phase co-existing with a columnar phase have shown such peaks very clearly [1].)

In conclusion, we have been able to measure the alignment of colloidal platelets in a magnetic field up to 7 T. Furthermore, we were able to increase the orientational order of nematic phases of these particles by rotating the samples in low magnetic fields. Calculations of the (para)nematic order parameter from these data are being done and will be completed in the near future.

[1] "The transition from a columnar to a smectic liquid crystal phase in suspensions of polydisperse colloidal platelets", DUBBLE report 26-02-111, September 2002