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NEMATIC VS LAMELLAR ORDER IN COLLOIDAL AQUEOUS SUSPENSIONS OF NANOSHEETS

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Abstract: Ordering 2D colloidal particles at the nanometer length-scale is currently a challenging and active research area in materials science.¹ Such ordering can spontaneously appear when anisotropic objects form liquid-crystalline phases. Well known for organic species, this tendency also exists for disk-like mineral particles², thus leading to nematic, lamellar and columnar mesophases. In the case of nanosheets (defined as two-dimensional crystallites of sub-micronic diameter and of well-defined, small, thickness comparable to the unit-cell size), nematic and lamellar phases were reported for clay particles, graphene and graphene oxide, titanates or niobates but so far, no columnar phase was ever described for such objects. Among nanosheets, phosphoantimonate single layers ($\text{H}_3\text{Sb}_3\text{P}_2\text{O}_{14}$) were shown to display a liquid-crystalline lamellar phase³ comprised of planar solid-like sheets (i.e. in which all atoms involved in a layer are covalently bonded) dispersed in water. Upon dilution, the lamellar spacing could be increased 100 fold, leading to 1D periodicities tunable from 1.5 to 225 nm. For such systems, significant differences were observed for two compounds of the same family, $\text{H}_3\text{Sb}_3\text{P}_2\text{O}_{14}$ and HSbP_2O_8 , as the former leads to a lamellar phase whereas the latter only shows a nematic phase. Likewise, clay and graphene nanosheets self-assemble into nematic phases whereas niobates and phosphates sometimes display lamellar phases. The physical origin of such a difference in behavior remains largely unknown so far but might be ascribed to differences in sheet size, rigidity, polydispersity, and/or interaction potentials.

In this context, we will present the results of our recent detailed structural investigation by polarized-light optical microscopy and x-ray scattering of both lamellar and nematic phases in the system of phosphoantimonates.⁴

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