Final report on Short Research Visit, "Self-assembly of magneto-mechanical meta-materials: theory and experiment"

Dr R Mike L Evans (School of Mathematics, University of Leeds), visited Dr David Fairhurst (School of Science & Technology, Nottingham Trent University) 11-15 June 2018. Reciprocal visit (DJF to Leeds) 17-19 September 2018.

We investigated the feasibility of using self-assembly in complex fluids to construct a novel metamaterial from simple colloidal ingredients. The theoretical approach (by Monte-Carlo simulation - see Fig. 1) predicted the existence of unprecedented magnetostriction (orders of magnitude larger than in known materials) in a gel formed of suitable soft colloidal gels with superparamagnetic cores. The simultaneous experimental approach provided useful knowledge of appropriate techniques and particle design.

During the first visit (and subsequent Skype meetings), DJF & RMLE supervised NTU-funded project summer-student Lorenzo Espinoza-Brown, who learned experimental techniques and data analysis (Fig. 2), and will present a poster of his findings at NTU. Nano-particle samples were donated by NTU spin-out Farm2Pharm (Director Gareth Cave). RMLE gave a seminar to the NTU School of Science & Technology and also had useful discussions with NTU academics including DJF, Lucas Goehring, Fouzia Ouali, Gareth Cave, Ben Dickins and Karen Davies.

During the second visit, data were analysed in order to match simulation results to experimentally accessible parameter regimes. DJF had useful discussions with Leeds academics including RMLE, Johan Mattsson, Daniel Read, Olivier Cayre, Tim Hunter and Stephen Fitzgerald.

RMLE presented a poster of preliminary findings to the UK Fluids Conference, Manchester 4-6 Sept 2018. After further simulations, more complete results will be submitted for publication in a peer-reviewed journal such as Physical Review E. We are planning follow-up research on related structured fluids.

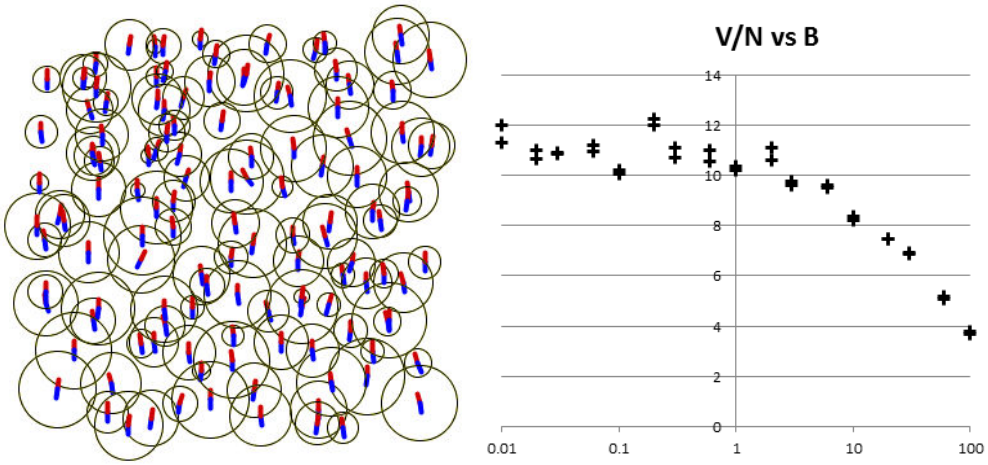

Figure 1: (Left) A configuration of the Monte-Carlo simulation of soft colloidal particles (circles) with magnetic cores, subjected to a large magnetic field. (Right) Simulation results of specific volume versus applied field strength, at fixed temperature and pressure, demonstrating collossal magnetostriction.

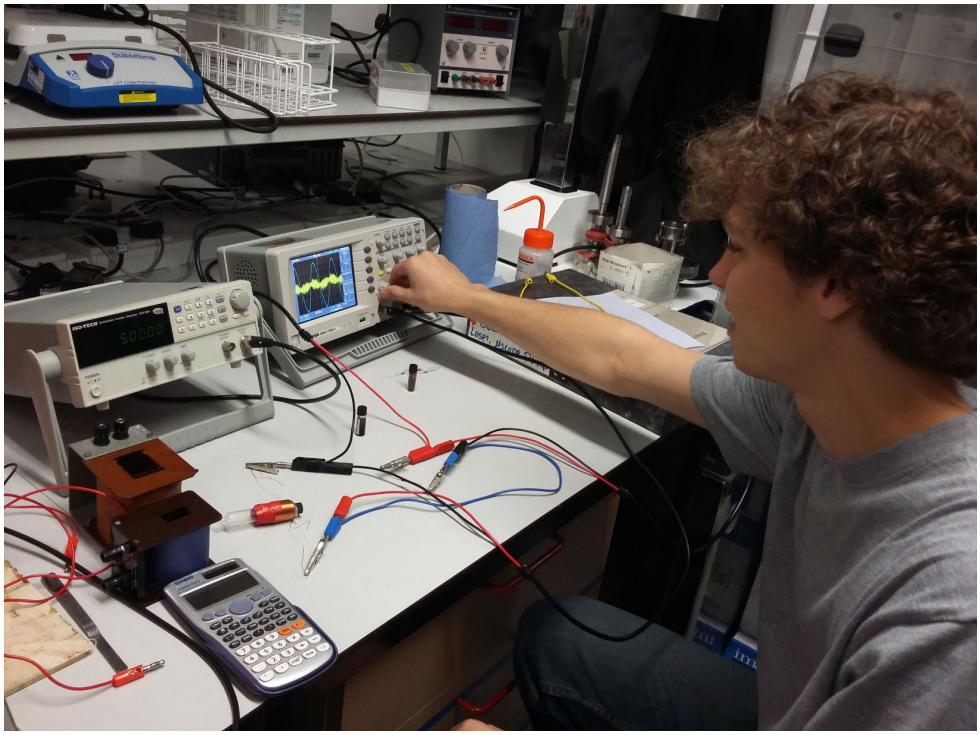

Figure 2: NTU summer project student Lorenzo Espinoza-Brown measuring the frequency-dependent linear magnetic permeability of a test sample of colloidal superparamagnetic particles.