ID de Contribution: **6**   Type: **Plenary talk**

On Einstein's effective viscosity formula

mardi 16 novembre 2021 16:15 (45 minutes)

In his PhD thesis, in order to devise an experiment to measure the Avogadro number (worked out later by Perrin), Einstein derived an explicit first-order expansion for the effective viscosity of a Stokes fluid with a random suspension of small rigid particles at low density.

This formal derivation is based on two assumptions: (i) there is a scale separation between the size of particles and the observation scale, and (ii) particles do not interact with one another at first order.

In modern terms, the first assumption allows to prove a homogenization result and to rigorously define a notion of effective viscosity tensor. The second assumption allowed Einstein to give an explicit first-order expansion of this effective viscosity at low density by considering particles as isolated.

This is more subtle since the effective viscosity is a nonlinear nonlocal function of the particles. The aim of this talk is to give a rigorous justification of Einstein's first-order expansion at low density in the most general setting, and discuss higher-order corrections.

This is based on a joint work with Mitia Duerinckx (Paris-Saclay).

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