Rigorous derivation of the Fick cross-diffusion system from the multi-species Boltzmann equation in the diffusive scaling

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In this talk, I will present the arising of the Fick cross-diffusion system of equations for fluid mixtures from the multi-species Boltzmann equation in a rigorous manner in Sobolev spaces. To this end, we formally show that, in a diffusive scaling, the hydrodynamical limit of the kinetic system is the Fick model supplemented with a closure relation and we give explicit formulae for the macroscopic diffusion coefficients from the Boltzmann collision operator. This allows to emphasize the differences at the formal level between the Maxwell-Stefan and the Fick cross-diffusion systems.

Further, the proof of the convergence relies on a perturbative Cauchy theory in Sobolev spaces for the constructed Fick system (which turns out to be a dilated parabolic equation), and the stability of the Fick Maxwellian for the multi-species Boltzmann equation (applying a recent result by Bondesan and Briant, CMP'21).

This is a joint work with Marc Briant.