The flow of liquid helium in restricted geometries

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This lecture deals with the flow properties of thermal excitations in quantum fluids [1], i. e. quasiparticle gases like phonons and rotons in superfluid ^{4}He as well as Landau and Bogoliubov quasiparticles (bogolons) in normal and superfluid ^{3}He. Of particular interest is the limit of low temperatures where the excitation gas becomes more and more dilute and the excitations travel essentially ballistically. If the quasiparticle systems could be made infinitely extended, only *inelastic* (two– or three) quasiparticle–collisions would be relevant. As a consequence, the mean free path of the excitations would diverge exponentially (rotons, ^{3}He–B bogolons) or with a power–law (phonons, Landau quasiparticles, ^{3}He–A bogolons), at low temperatures.

However, every experimental arrangement for the measurement of flow properties has a *finite size* by which surfaces, impurities, etc. and hence additional (elastic) scattering processes are introduced. Here I restrict myself to the distinction of two cases: First, finite size effects introduced by surfaces, and second, impurities immersed into the bulk quantum liquid in the form of silica aerogel strands.

As a consequence of surface scattering one encounters modifications of the Hagen–Poiseuille flow, of the transverse surface impedance and hence of the shear viscosity of the excitation gas, leading to what is known as the *velocity slip effect* and the *Knudsen transition*. Consequences from (impurity) scattering off aerogel strands include the transition between Hagen–Poiseuille flow with slip (parabolic velocity profile) and Drude flow (flat velocity profile) [2]. Within the time limitations of this lecture these phenomena are derived and discussed theoretically and the results are compared with available experimental observations.

[1] **Slip in quantum fluids**
D. Einzel and J. M. Parpia, J. Low Temp. Phys. **109**, 1 – 105 (1997)

[2] **Liquid ^{3}He in aerogel: crossover from Drude's to Hagen–Poiseuille's Law**
D. Einzel and J. M. Parpia, Phys. Rev. Lett. **81**, 3896 (1998)