A tilting AFM for cylindrical probe measurements

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1. Abstract

In the last two years we have developped a method to perform capillary force and microrheology measurements with a home-mae AFM, by dipping a cylindrical probe, attached to an AFM cantilever, in the fluid of interest. This method was inspired by the work of Xiong *et al.* [1]. Since the cantilever itself is not immersed in the fluid, note that the studied fluid can be completely opaque.

In this poster, we explain the principle of the cylindrical probe measurements as well as two effets affecting the capillary force and microrheology measurements. Finally, we perssent the principle of the tilting AFM setup we are currently building to first characterize these two effects and then be able to minimize the supurious effects on the measurements by working at an optimal θ angle.

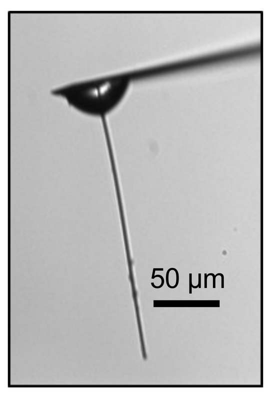
2. Cylindrical probe AFM experiments

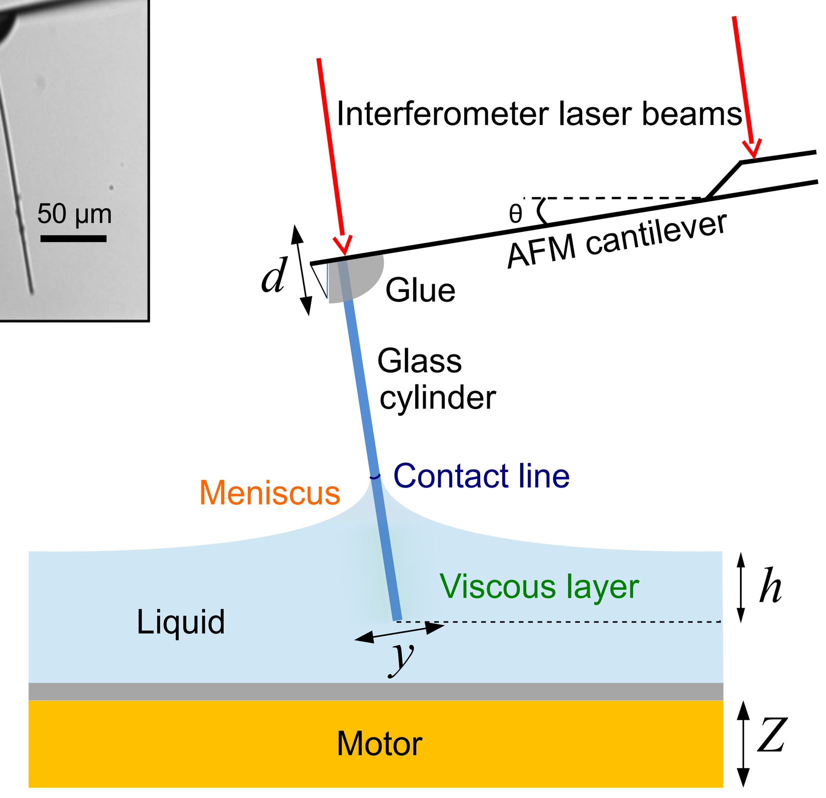
Static measurements:
mean deflection ⟷ capillary force

Dynamic measurements:
added stiffness ⟷ pinning of the contact line
added mass ⟷ mass of the moving liquid
added dissipation ⟷ dissipation in the viscous layer
+ in the liquid meniscus
+ at the contact line

Liquids used:
alcanes
silicon oils
chosen for their wettability

Cylindrical probe characteristics:
around 250 µm long
a few µm in diameter





Schematic representation of the setup

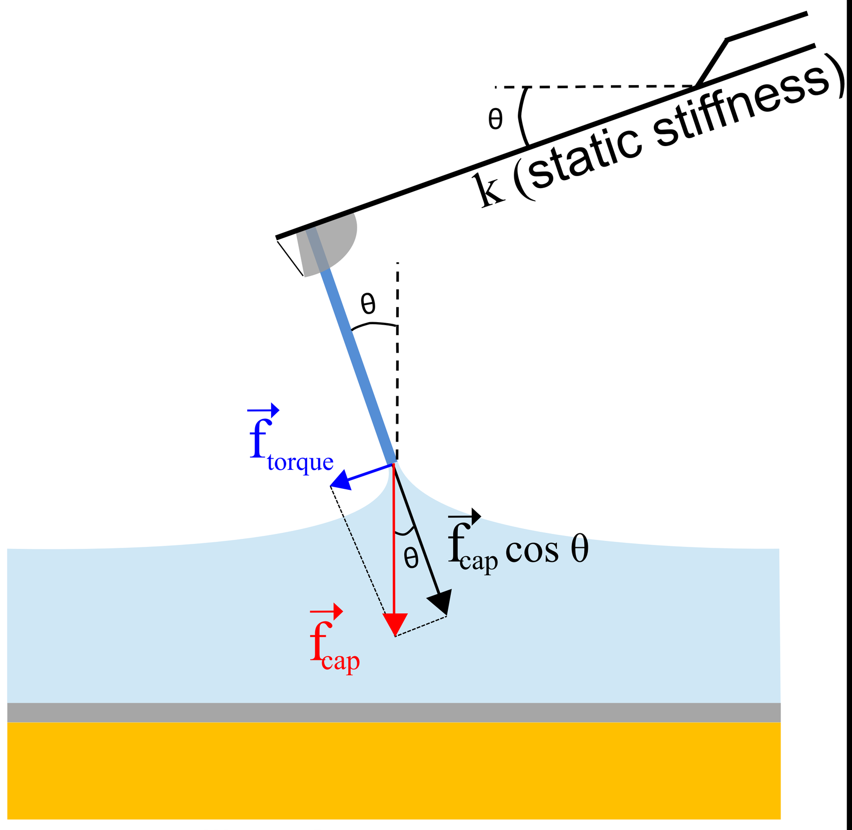
3. Capillary force shift (torque effect)

The wetting measurement is analogous to the Wilhelmy plate method [2].

If θ is not zero, part of the capillary force (f_{torque}) creates a torque on the cylindrical probe.

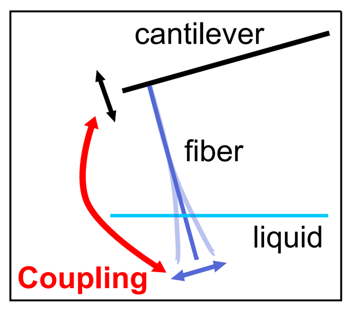
This torque alter the cantilever deflexion as a function of θ, so that $d_{mes} = -\frac{f_{cap}\cos\theta}{k} + d_{torque}(\theta)$
The change in deflexion is translated as a capillary force shift.

The discrepancy can go from 20% up to 50% for the expected capillary force if this effect is not taken into account

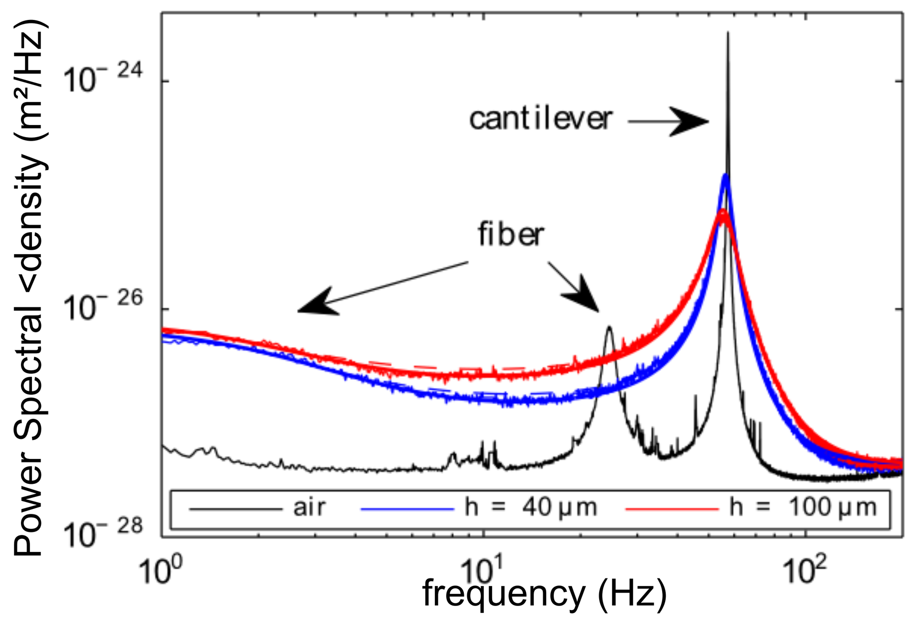


capillary force measurement

4. Mode coupling



When the fiber is dipped, a coupling beween the oscillations of the fiber and the cantilever is observed [3].
This coupling effect complexifies the rheology measurements since the data analysis requires to take this coupling into account.



Is this coupling θ dependant?

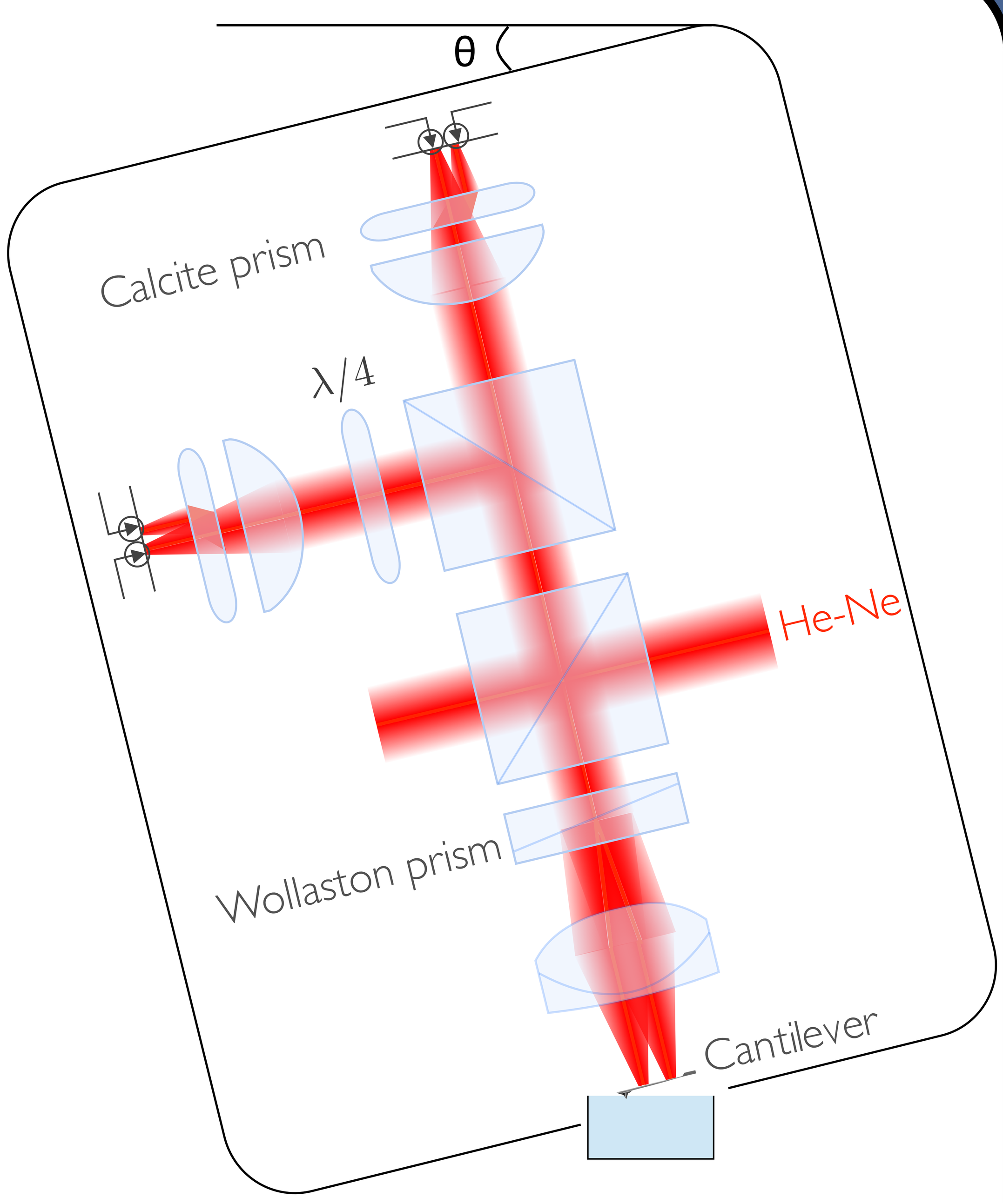
If so, can we reduce the coupling by working at an optimal θ?

5. Tilting the AFM

The cantilever deflexion is measured by a quadrature phase interferometer [4] in a home made Atomic Force Microscope.

Advantages:
- absolute calibration
- wide deflexion range (up to a few µm)
- resolution ~10fm/√Hz

The cantilever and interferometer are placed on a rotating plate that enables us to control the parameter θ
The rotation axis is placed at the level of the cantilever.



6. Conclusion

Take home:
- Gluing a fiber to the tip of the cantilever enables microrheology and weting measurements

- Tilting the AFM could reduce the coupling between the vibrations of the fiber and the vibrations of the cantilever. It is also a way to investigate the influence of θ on the observed torque effect.

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[1] Xiong et al., PRE 80 (2009)
[2] A.W.Adamson, Physical Chemistry of Surfaces, Wiley & Sons (1976).
[3] Devailly *et al.*, *EPL* 106 (2014)
[4] Bellon *et al.*, Opt. Commun. (2002).

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