# High resolution measurements of nanometrics displacements and lasers testing with quadrature phase interferometry

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## Introduction

Nowadays, in the nanoscale physics, we need more and more accurate and resolved instruments. In this sense, the interferometry is a powerful and versatile tool. Based on the work of C. Schonenberger[1] P. Paolino[2] and L. Bellon[3], we built a quadrature phase interferometer to test a piezoelectric platform (E712, PI Instruments) and test the wavelength stability of some lasers.

## Basics

This interferometer can easily be adapted to different configurations as illustrated in Fig.1 for AFM deflexion measurements and Fig.2 for a nanopositioner test.

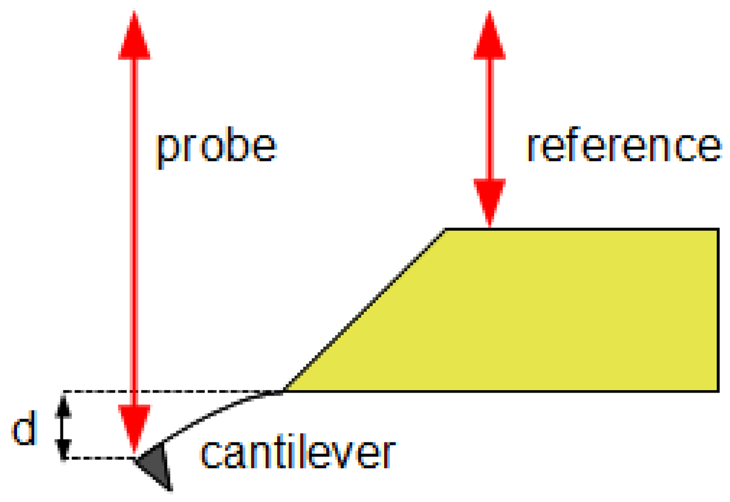


**Figure 1.** Beams of the interferometer for deflexion measurement *d* in AFM applications.

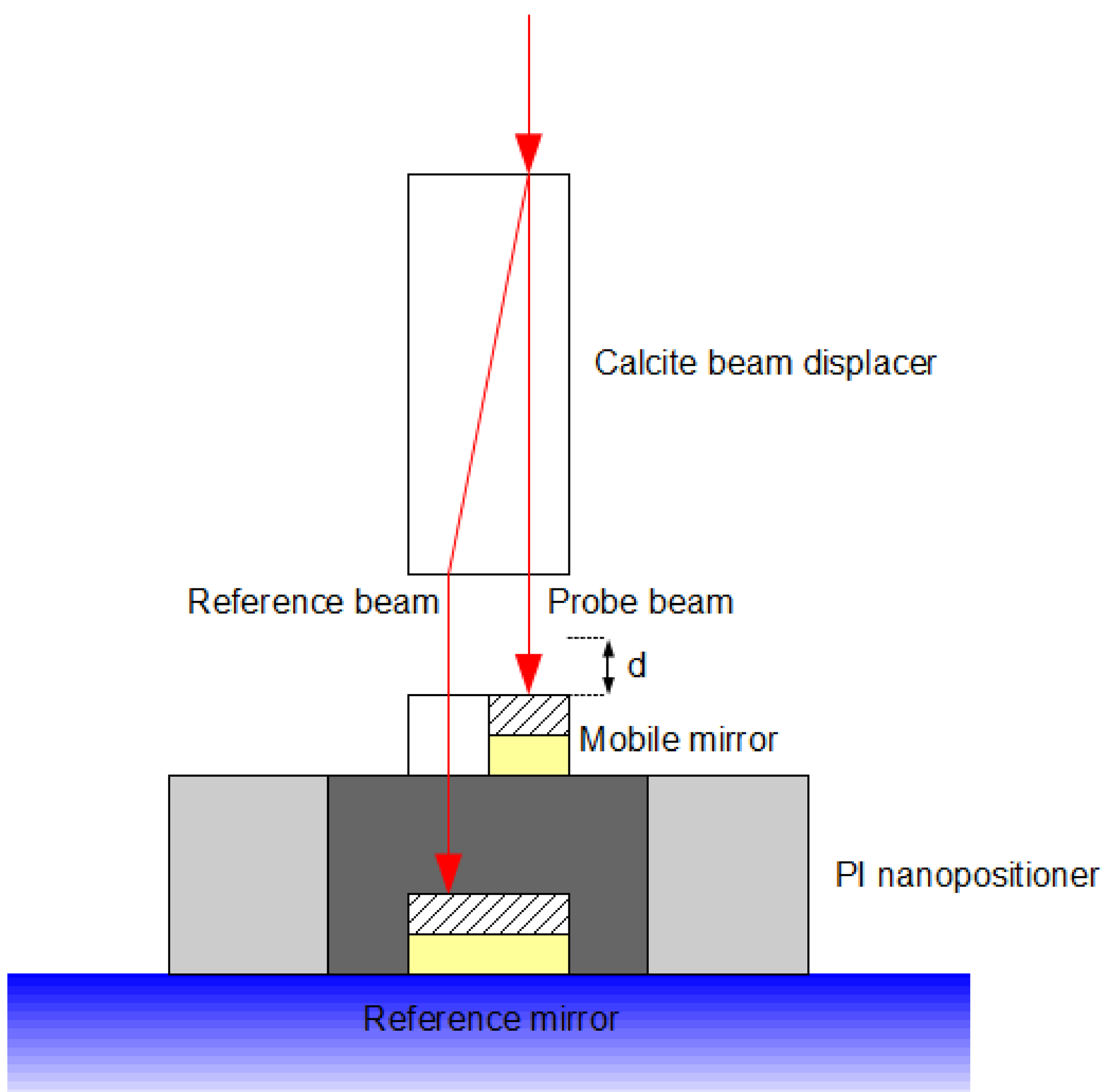


**Figure 2.** Setup used for nanopositioner testing, the calcite beam displacer is used to split a single beam into two beams with perpendicular polarization, the mobile mirror is mounted in the mobile part of the nanopositioner and the reference mirror is fixed to the optical table, solidary to the interferometer reference system and to the PI nanopositioner.

## Measurements

To test lasers we configure a fixed setup for the two beams and report in Fig.3 the relative shift of the wavelength in ppm (part per million) and in Fig.4 the power spectrum density (PSD) of the equivalent detection noise in the lasers tested.

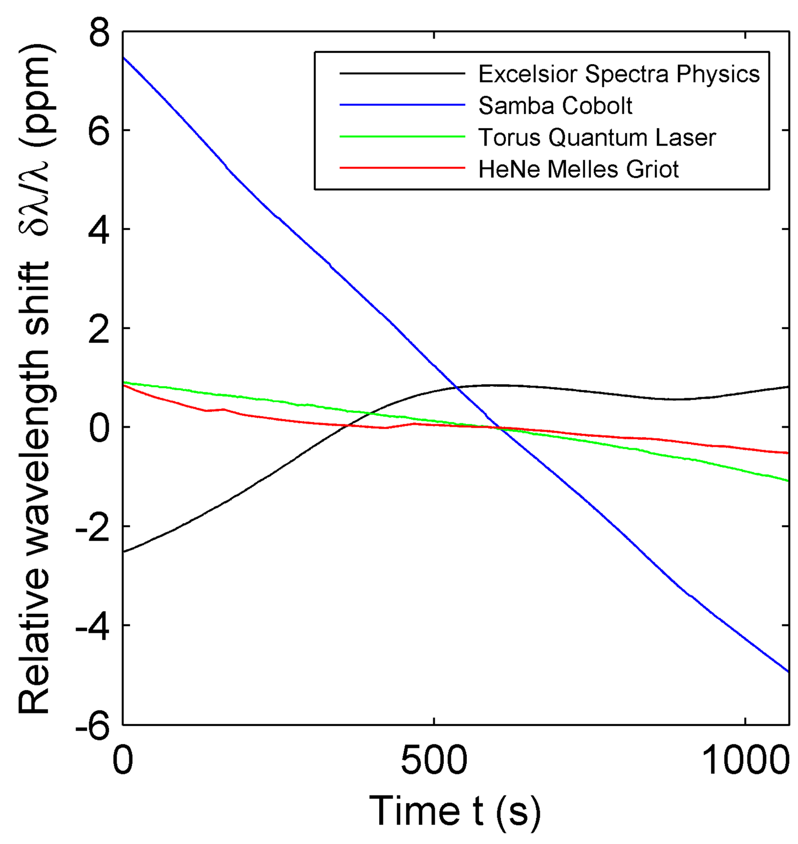


**Figure 3.** Relative wavelength shift of the lasers tested in our interferometer, the variations are mainly due to thermal drifts, the big slope in the Samba Cobolt is due to non optimal control parameters in the thermal control of the cavity.

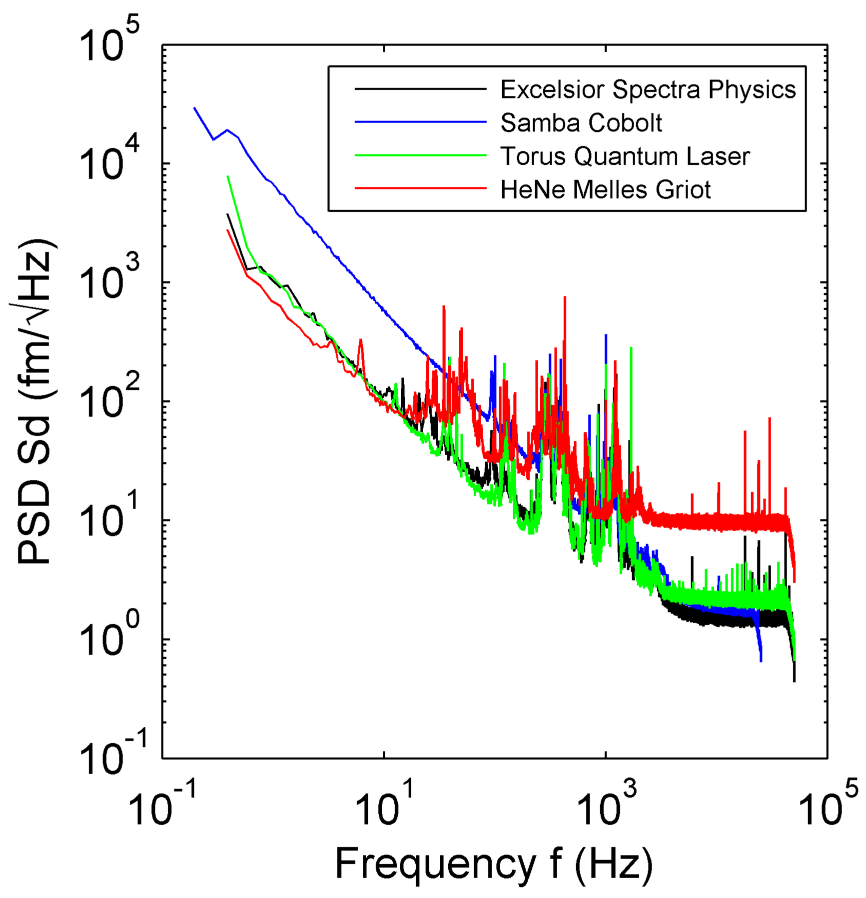


**Figure 4.** PSD of noise in the lasers tested. We can identify three zones of the noise, first one is 1/f type, the second one is a remanent mechanical noise of the setup and the third one is the shot noise of photodetectors in the interferometer. We can see a reduction of the shot noise in more empowered lasers, the red line is a HeNe laser of 2mW and the others are in the order of 100mW

In the Fig.5 we plot the PSD of the noise under different conditions for a steady position of the PI nanopositioner.

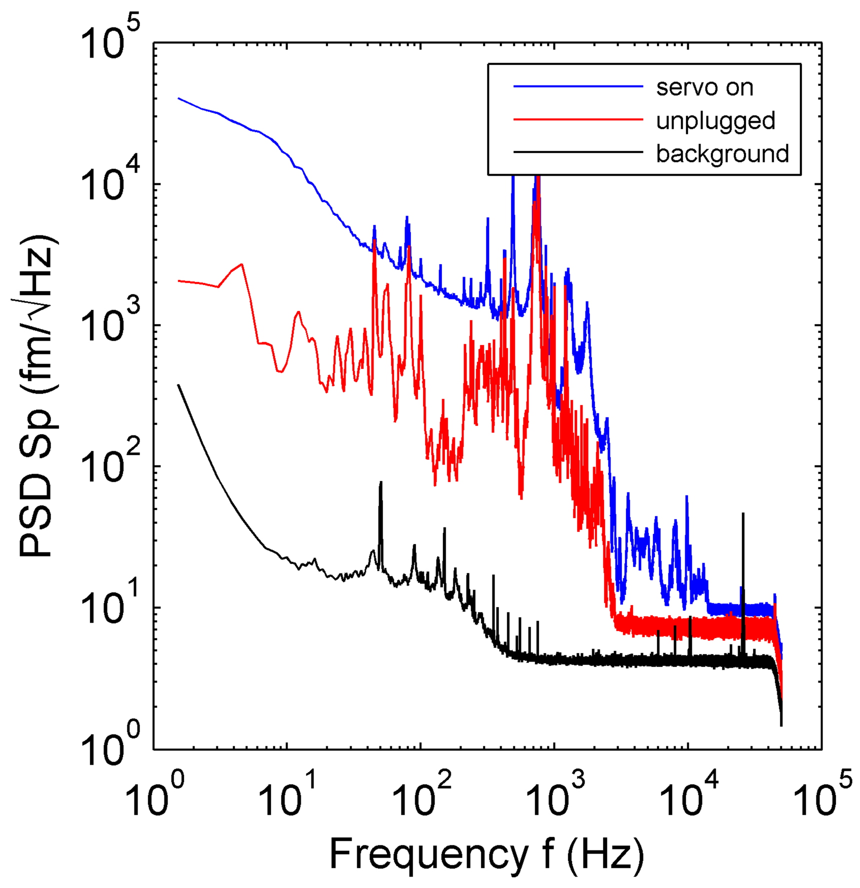


**Figure 5.** We calculate the PSD of different conditions for the nanopositioner. In the ***servo on*** curve the platform is connected to the controller with a steady setpoint, the ***unplugged*** is unconnected from the controller and ***background*** is the signal of the two beams of the interferometer reflected on a single steady mirror (measurements with a HeNe Melles Griot laser). The background noise is below 10pm/√Hz above 10Hz for every operating conditions.

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## References

[1] C. Schonenberger and S.F. Alvarado. Review of Scientific Instruments **60**, 3131-3134 (1989)
[2] P. Paolino PhD Thesis, ENS de Lyon, 11 2008.
[3] L. Bellon, S. Ciliberto, H. Boubaker, and L. Guyon, Optics Communications **207**, 49-56 (2002)