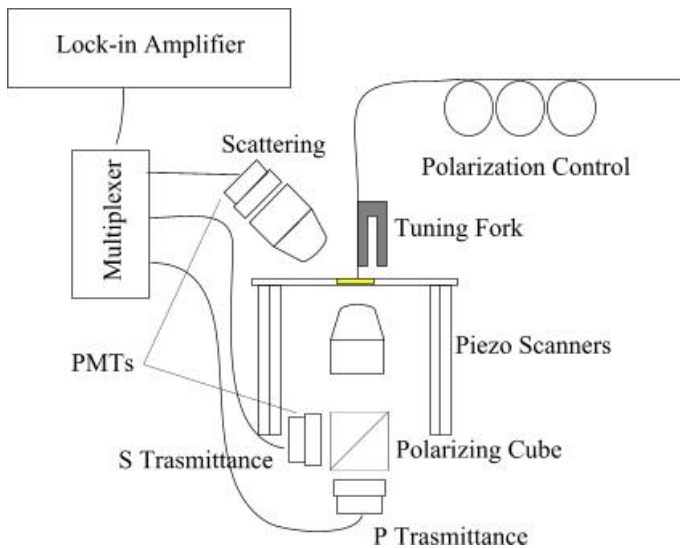
Local measurements of optical birefringence and order parameter in twisted nematic cells by confocal microRaman and by a modified SNOM

PAIS LIMAD, Parma group:

Paolo Camorani, Luigi Cristofolini, Marco Fontana

SNOM setup modification

Starting point: SNOM, A.P.E. research. No polarization analysis

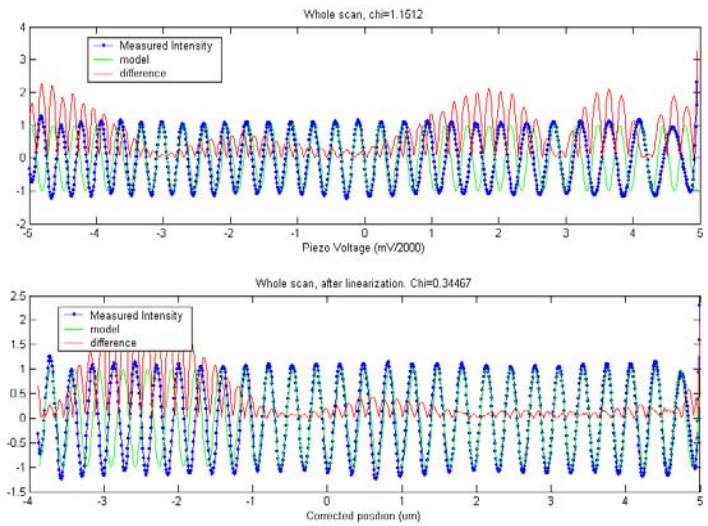


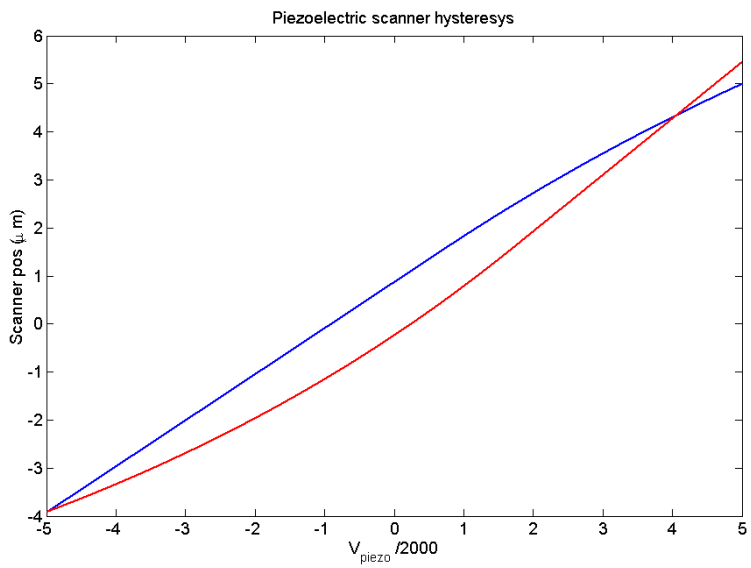
Single mode optical fiber (core 5 μm^2) looped on a fiber polarization controller (Thorlabs FPC030).

Z-piezoelectric scanner non-linearity

In principle, 1μm each 2000mV

Fabry-Perot-type interferometry (λ=650nm)





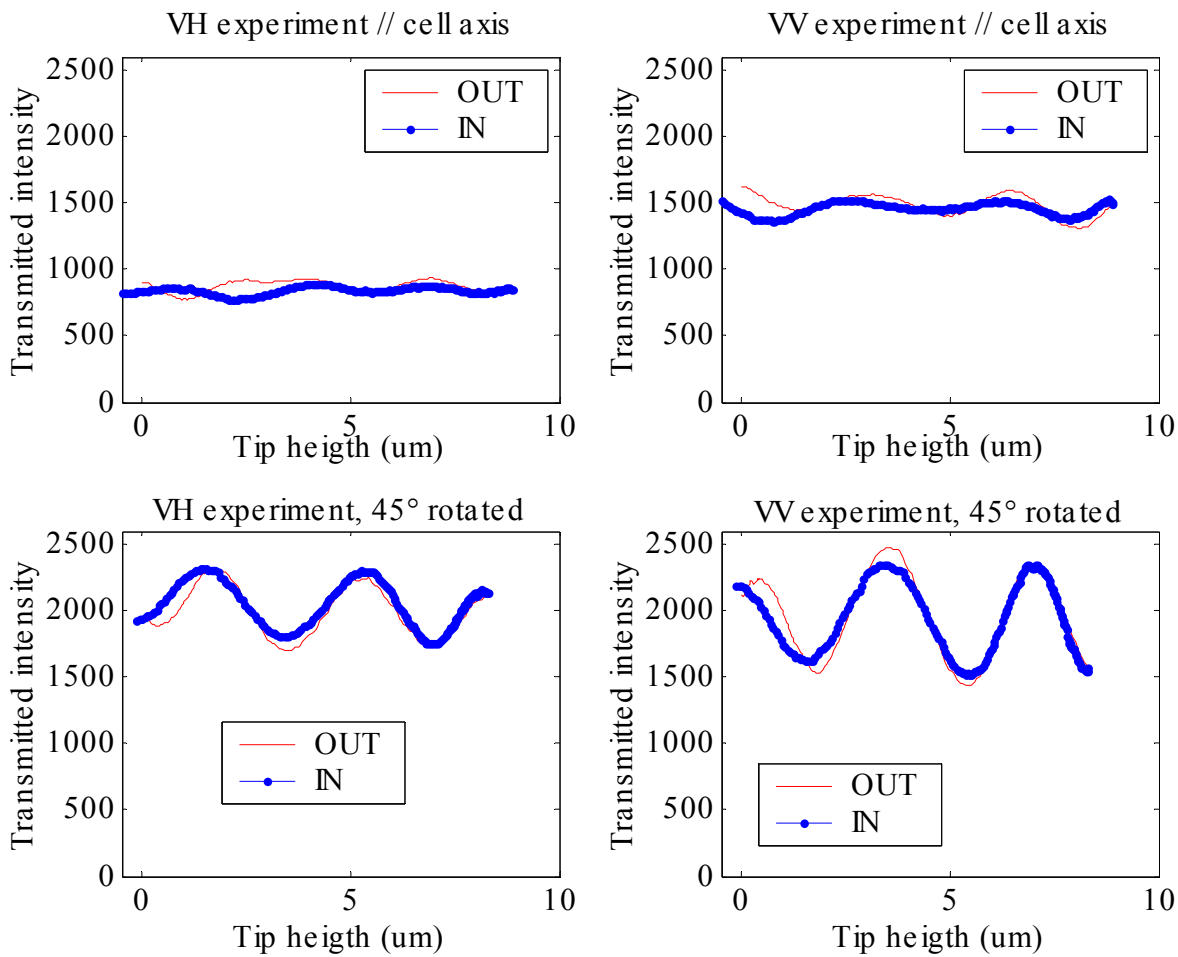
In situ birefringence measurements.

Depolarisation experiments:
polarizer and analyser set parallel (VV) and perpendicular to each other (VH)

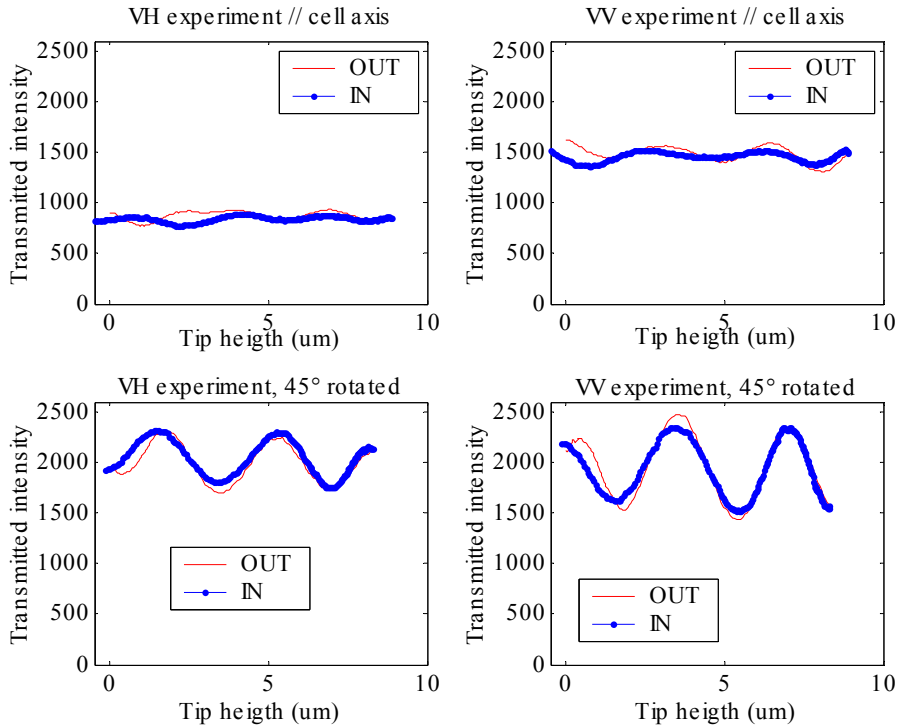
Incoming polarization:
parallel or rotated by 45° WRT the optical axis induced by the PVCN-F surface

In vacuum the extintion ratio is about 85%, when a LC cell is interposed, extinction ratio drops to 35% even when teh fiber touches the bottom wall

Results


VH experiment // cell axis
VV experiment // cell axis
VH experiment, 45° rotated
VV experiment, 45° rotated
Transmitted intensity
Tip heigth (um)
OUT
IN
0
500
1000
1500
2000
2500
0
5
10

Discussion



VH polarization parallel :small intensity is observed with almost no modulation
VV polarization parallel: large (X2) intensity with no modulation within 5-7% of the total transmitted light.

VH polarization rotated by 45°: large modulation of transmitted intensity.
VV polarization rotated by 45°: large modulation of transmitted intensity.

Uniform monodomain, with nematic axis parallel to the axis of preparation of the cell.
From the z-spacing of the fringes of the bottom panels we estimate an anisotropy of refractive index in our cells $\Delta n=0.18\pm0.02$.

Depolarization microRaman

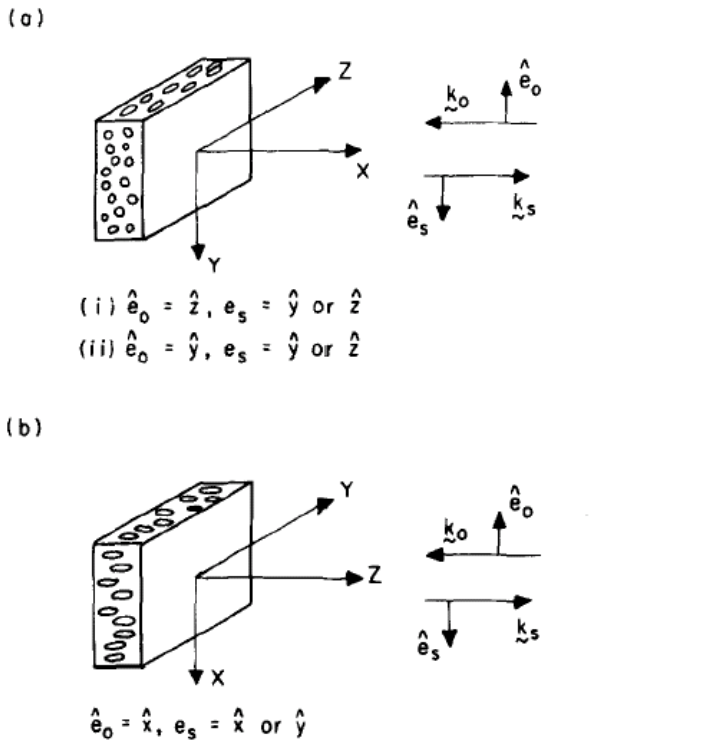


FIG. 2. Experimental geometries. (a) Optical axis of sample parallel to sample surface, (b) Optical axis of sample perpendicular to sample surface.

For a uniaxial vibration, from the VV VH experiments, the depolarisation ratios

$$R_1 = I_{yz}/I_{zz} \ , \quad R_2 = I_{zy}/I_{yy} \ , \quad R_3 = I_{yx}/I_{xx}$$

are measured. (NB I_{ji} means impinging $i=x,y,z,$ analyser $j=x,y,z$) and the order parameters

$$\langle P_2 \rangle = 1/2 \ \langle 3\cos^2\theta - 1 \rangle$$

$$\langle P_4 \rangle = 1/8 \ \langle 35\cos^4\theta - 30\cos^2\theta + 3 \rangle$$

can be deduced

[Shen Jen et al. J Chem Phys 66, 4539 (1977)]

Confocal microRaman

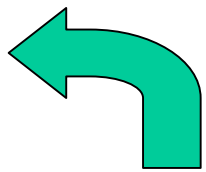
- On Silicon, 100X NA=0.90 λ=488nm, z-resolution δ=1μm
  λ=647nm, z-resolution δ=2.0μm
  50X ULWD NA=0.55 λ=647nm, z-resolution δ=8.0μm

- On a plain 5CB cell, 50X ULWD NA=0.55 λ=647nm, best confocal z-resolution δ=30.0μm

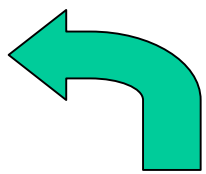
- We selected the C=C uniaxial stretching mode of 5CB located at 1650 cm^{-1}

Results

PVCN-F face		
Before pump	R_1=0.30(5)	R_2=2.0(1)
After pump	R_1=1.8(1)	R_2=0.31(5)
Polyimmide face		
Before pump	R_1=0.30(5)	R_2=2.1(1)
After pump	R_1=0.34(5)	R_2=1.8(1)



90° rotation of nematic versor!!



NO rotation

$S_2 \sim 0.5$

Conclusions: twisting can be obtained and tested by Confocal microRaman depolarization spectroscopy

CONCLUSIONS

- A SNOM setup has been developed to study in situ birefringence. It was tested in a particular case. Further tests on cholesteric phases (pitch ~1μm) are under way.
- Confocal microRaman experiments proved useful to detect order parameter S_2 on cell surfaces. Z-resolution has to be improved in order to track S_2 along z. For this, much thinner cell walls must be used.