

# Complex Interferometry Diagnostics of Laser Produced Plasmas

SILMI Reference Number 3433

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## Visited Partners:

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### **Prof. Sandor Szatmári**

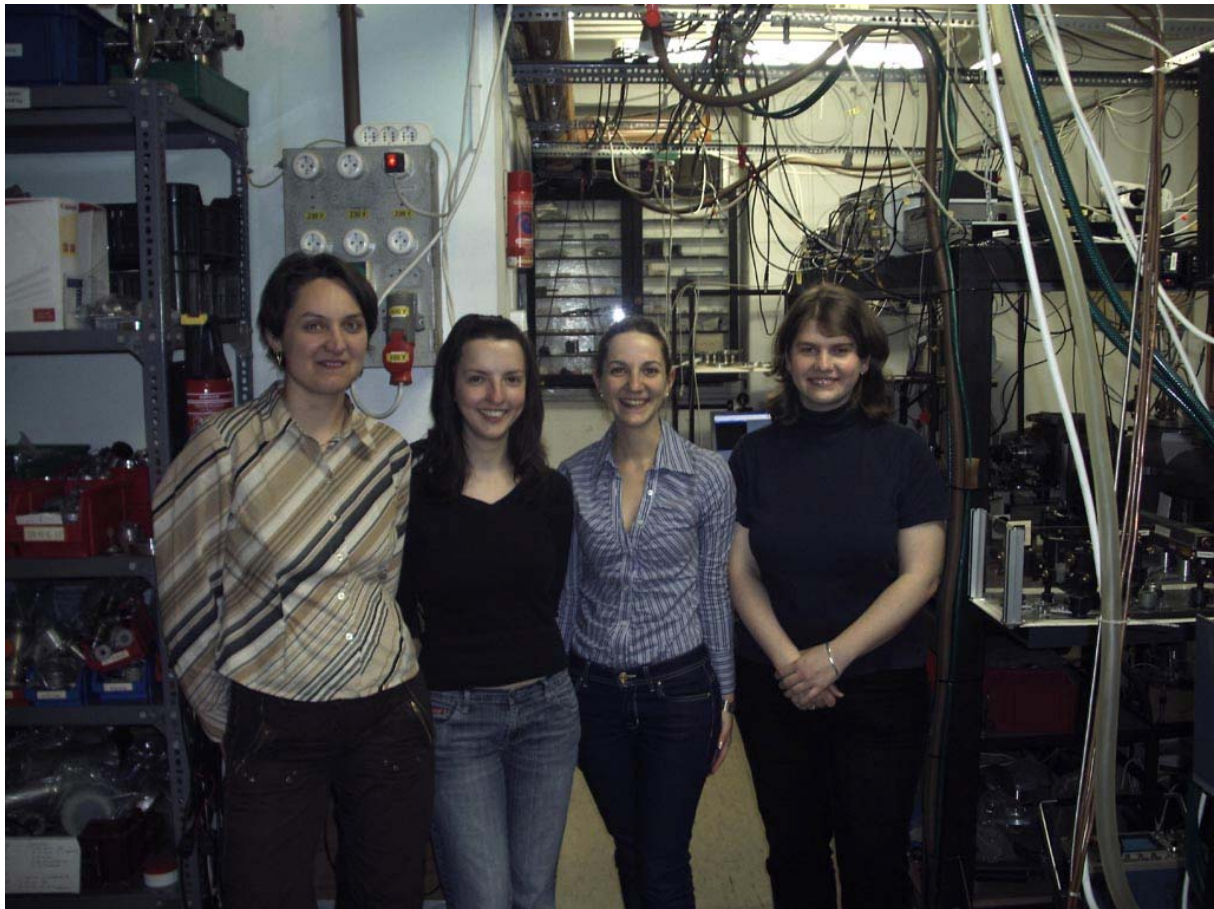
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### Purpose of the visit:

The main purpose of this visit (**April 26 till April 30, 2010**) was to further broaden already existing collaboration between the *Czech Technical University in Prague* (Prof. Milan Kalal) and our Hungarian counterparts: *KFKI Research Institute for Particle and Nuclear Physics* (Prof. Istvan Földes) and *University of Szeged* (Prof. Sandor Szatmari) in the field of high power laser applications which started in 2008.

*Experiments* with laser produced plasmas in the **High Intensity Laser Laboratory (HILL)** at the **University of Szeged** were planning to be performed. *Ionization of the air* by the HILL's femtosecond laser was selected for testing of both the *laser performance* (beam *quality* and *stability*) as well the *complex interferometry diagnostics*. These relatively simple experiments were identified as having (if successful) a potential for future *interesting* extensions.

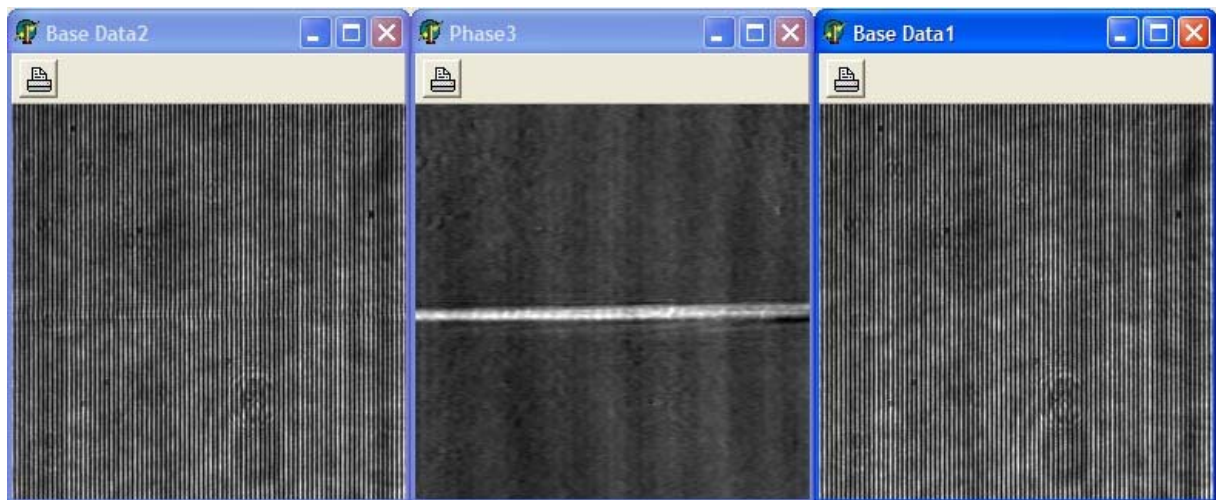
For this purpose an *upgrade* of the *complex interferometer* originally installed in 2008 was to be realized to further improve its performance in laser produced plasma *diagnostics with high resolution*. Also an *upgraded version* of the *analyzing software* was to be provided and a *training* of its usage conducted both for the *local staff* as well as for one undergraduate student (Chiara Liberatore) from the University of Milan Bicocca (UMB) from the group of Prof. Dimitri Batani.



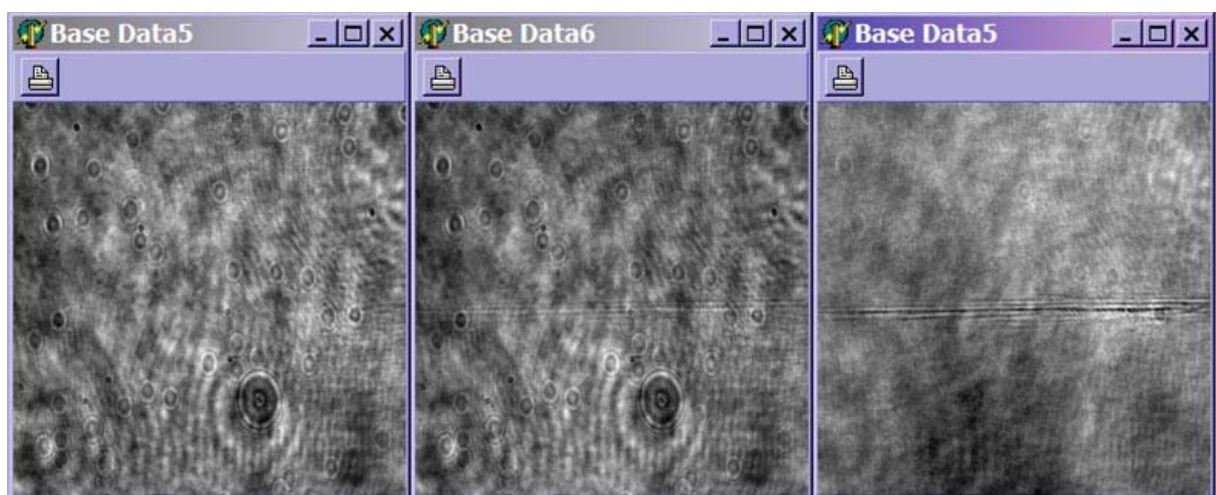
From the left to the right: *Rita* (HILL staff), *Angela* (HILL staff), *Chiara* (undergraduate student from UMB), and *Michaela* (graduate student of Prof. Kalal from CTU in Prague) in the HILL during experiments.

### Description of the work carried out during the visit:

1. Quality and stability of the HILL fs laser was verified.
2. *Training* in the usage of the upgraded version of the *analyzing software* was realized.
3. Upgraded version of the *complex interferometer* was accomplished and successfully tested.
4. Data from several hundreds of shots (both *interferograms* and/or *shadowgrams*) were recorded during the week for their *subsequent analysis*. Two *examples* of preliminary analysis are shown below for illustration.



Examples of interferogram *recording* and *analysis*. From the left to the right: interferogram *with signal* (laser produced plasma in the air); analyzed *phase shift* combining data from *both* interferograms; interferogram *without signal* used as a *reference*. It is clearly visible that even if the overall quality of both interferograms (due to various reasons) is far from perfect, their reproducibility is very good. This factor is *essential* for *high quality analysis*.



Examples of *shadowgram recording* and *analysis*. From the left to the right: shadowgram *without signal* used as a *reference*; shadowgram *with signal* (laser produced plasma in the air); much better quality *shadowgram* by combining data from *both* shadowgrams.



### Description of the main results obtained:

1. *Complex interferometry diagnostics* was *fully implemented* and *successfully tested* both from the point of *hardware* as well as *software*.
2. *Experiments with laser-gas interactions* were performed. *Data* were recorded by *interferometry* as well as *shadography* and will be used for a subsequent analysis.

### Future collaboration with host institution:

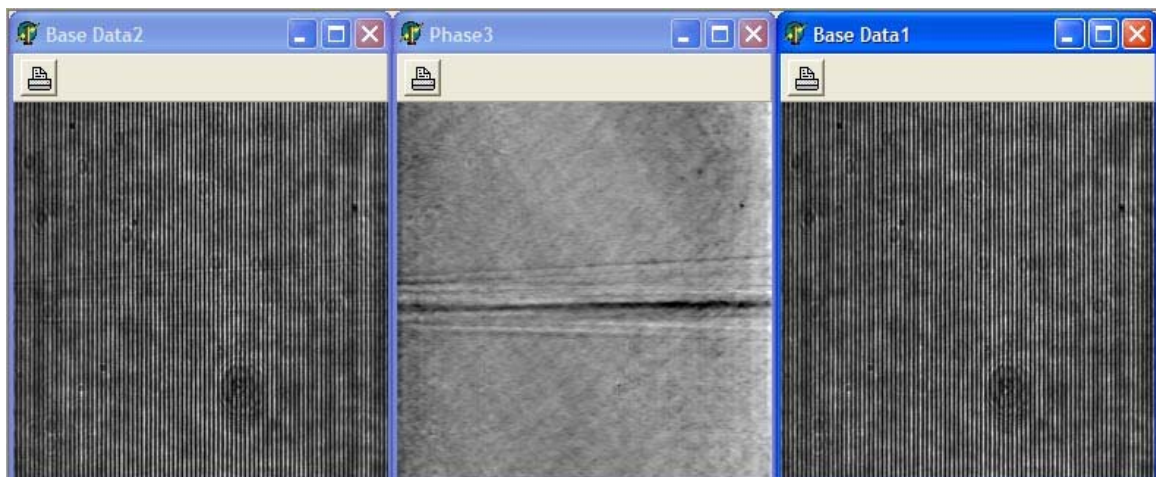
1. Continuation of these experiments will take place during the *next two weeks* as the local staff was sufficiently trained to be able to act *independently* (with consultations available over the internet). This is rather important as *after* this period the laser itself will be disassembled and transported to another place - thus becoming unavailable for several months.
2. Agreement was achieved that as soon as the laser will be transported to its new location and once again it will become operational, these successful preliminary experiments should be followed by a much more focused round of experiments as part of the new *LaserLab Europe* project to be submitted soon for evaluation.

### Projected publications/articles resulting or to result from your grant:

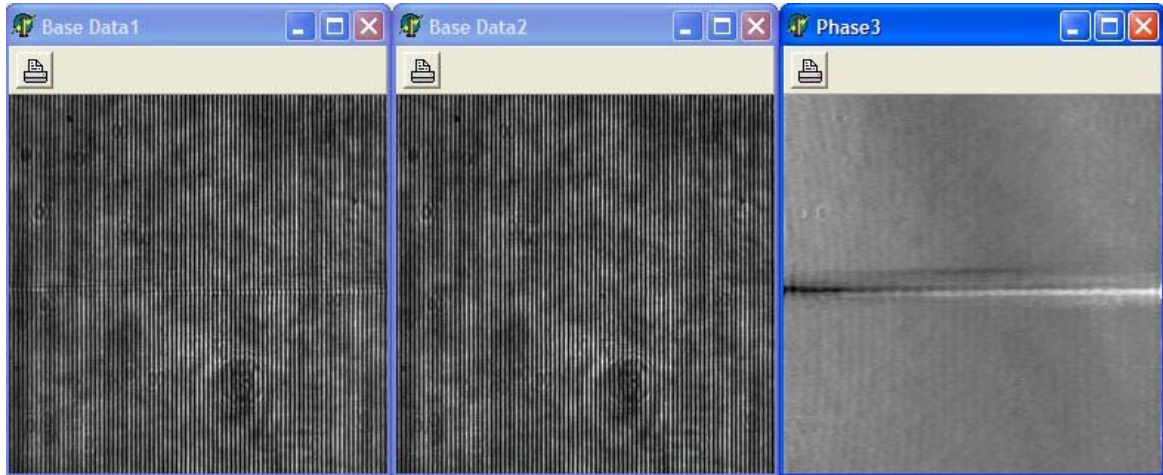
It is expected that after the analysis of data obtained during the experiments performed (even if having only a *preliminary* character) there should be enough of *sufficiently interesting* material for preparation of at least one *publication* in a *suitable scientific journal*. Presentations at international conferences are also most likely.

### Other comments:

1. It was proven during these experiments that under the right circumstances the *complex interferometry approach* can provide *resolutions* comparable to those obtained from *shadowgrams* - but providing also information about *plasma densities* - see the illustration bellow and compare it with the previous figure.



2. Care should be taken in *interpretation* of data analyzed from *interferograms* when the *Fresnel bi-prism based Nomarski interferometer* is employed as these results can be *influenced* by the effect of the so called *compact interferometer design* [1]. This effect is clearly visible on the analyzed data below (the analyzed *phase shift* is changing its *sign* while going from the left to the right).



The best way how to *avoid* this effect would be to use either *spatially localized gas* (e.g. from a *gas jet*) or to use interference fringes *parallel* to the plasma structure. These types of experiments are now under preparation...

- [1] Kálal, M. - Slezák, O. - Martínková, M. - Rhee, Y.J.: Compact Design of Nomarski Interferometer and its Application in Diagnostics of Coulomb Explosions of Deuterium Clusters, *Journal of the Korean Physical Society* 56, No. 1 (2010) 287-294

**Travel Expenses (in detail):**

1. Air Ticket ..... 4365 + 2551 + 590 = **7506 CZK = 299.59 EUR** \*)
  2. Taxi Szeged (Hotel to University) ..... **1500 HUF**
  3. Train (Szeged to Ferihegy Airport) ..... **3080 HUF**
  4. Train Seat Reservation ..... **360 HUF**
  5. Bus from Railway Station to Airport..... **400 HUF**
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Local Transport in Hungary ..... **5340 HUF = 20.05 EUR** \*\*)

**Total Travel Expenses:**                      **299.59 + 20.05 = 319.64 EUR**

\*) **1 EUR = 25.045 CZK** on the day of **14.4.2010** when the **air ticket** was paid.

\*\*) **1 EUR = 266.28 HUF** on the day of **30.4.2010** when **all the transport tickets** were paid.

**Daily Allowance:**

**85 EUR** per day x **5** ..... **425.00 EUR**

**TOTAL EXPENSES for reimbursement:**..... **744.64 EUR**



Prague, May 6, 2010