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Laser Diode Velocimeter-Monitor Based on Self-Mixing Technique

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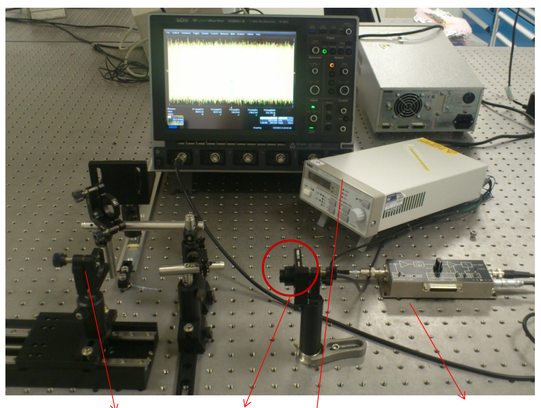
Abstract

A laser velocimeter shall be used for an in-detail characterization of atomic and molecular gas jets and allows investigations into the jet dynamics. Existing methods are currently not efficient enough, hard to build, and rather expensive. A laser velocimeter based on the self-mixing technique can provide unambiguous measurements from a single interferometric channel, realizable in a compact experimental setup that can be installed even in radiation-exposed environments

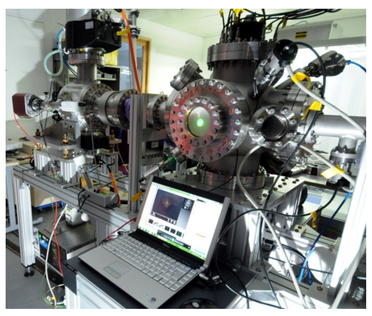
The Task

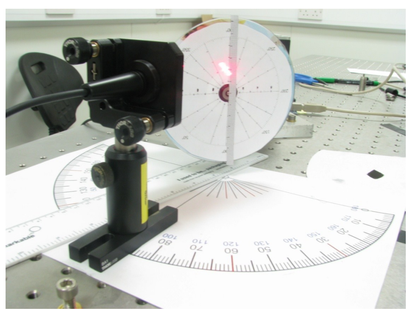
Gas targets are important for a number of accelerator-based applications. Detailed information about the gas jet is important for its optimization and the quality of the beam profile that can be measured with it.

- in-detail characterization of the gas jet,
  - *Gas: Ar, N_2, He*
  - *Velocities: 100-2000 m/s*
  - *Density:* 10^9 – 10^{12} particles/cm^3
  - compact and cheap



Solution: Self-Mixing Laser Diode

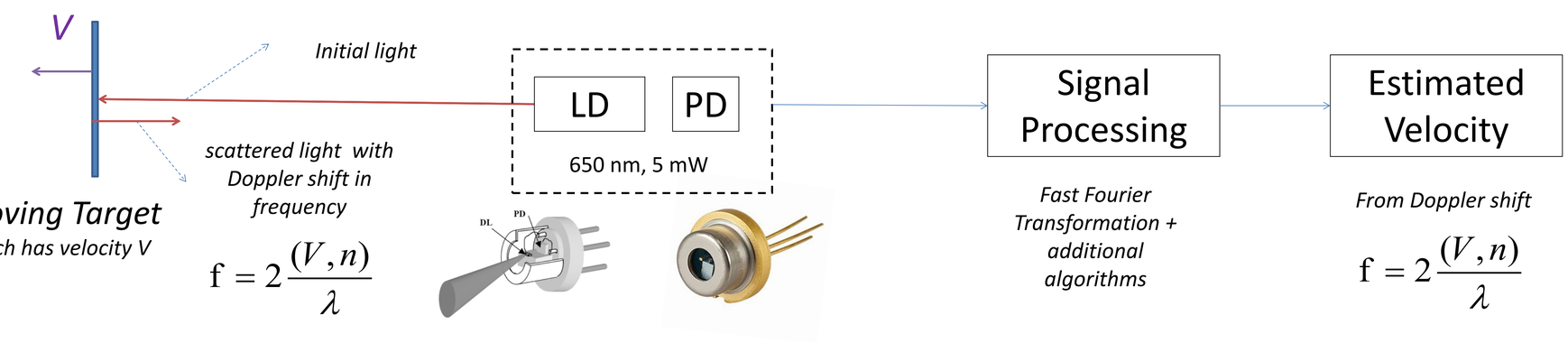




The main advantages of the self-mixing scheme with respect to traditional interferometer is possibility of

- *unambiguous measures ,*
- *single interferometric channel,*
- *compactness of the setup,*
- *low cost,*
- *ease of alignment*

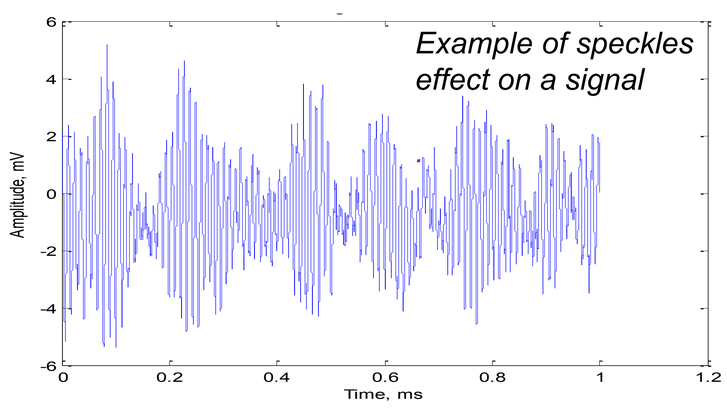
Experimental Set-up



Moving Targets

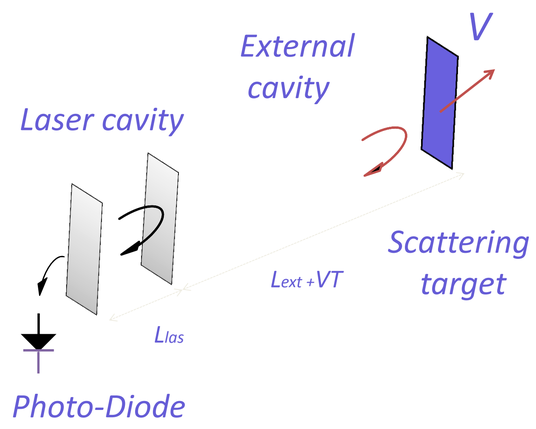
In order to test the SM method, experimental work was divided into several steps, including studies into different target objects:

- mirror (99% reflectivity);
- white paper (scattering);
- fluids;
- gas;



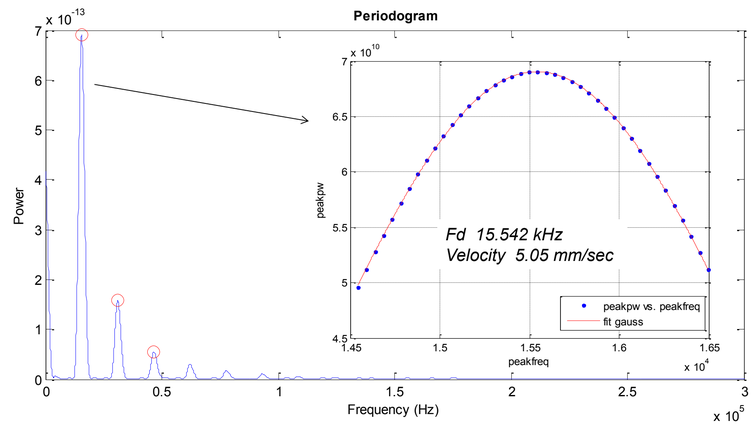
Self-mixing Technique

Small portion of light is reflected from studying object and is returned into the laser cavity. Then it is mixed with the original wave inside the laser.



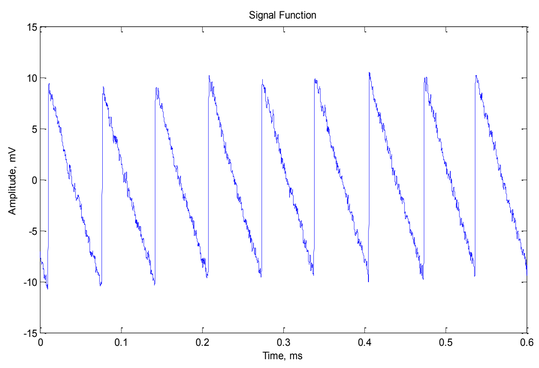
Signal Processing: FFT

A spectrum calculated by fast Fourier transformation (FFT) additional algorithms need to be used to suppress speckles and other noise



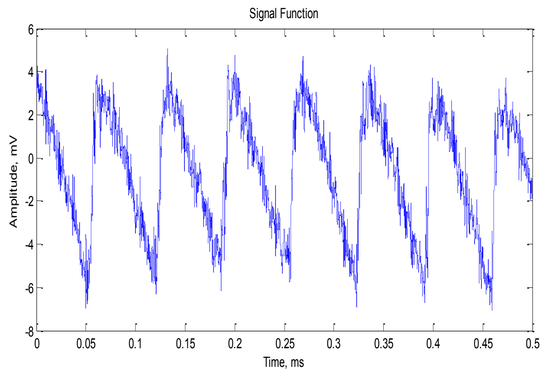
Reference Velocity 5.00 mm/sec (white paper, L=23 cm)

Target: Mirror (96 % reflectivity on 650 nm)



Distance between the target and LD, cm	Defined velocity, mm/s	Accuracy, %
20	5	1.1
30	5	0.7
40	5	0.9
50	5	0.5
20	10	1.0
30	10	0.5
40	10	0.8
50	10	1.4

Target: White Paper (60 % reflectivity on 650 nm)



Distance between the target and LD, cm	Defined velocity, mm/s	Accuracy, %
10	5	0.9
20	5	0.8
25	5	1.3
30	5	1.4
10	10	0.3
20	10	0.5
25	10	1.2
30	10	1.4

Conclusion

First results from investigations into a velocimetry based on laser self-mixing for the characterization of supersonic gas jets as used in advanced beam profile monitors were presented. The preliminary design of such monitor based on a LD and the SM technique shows good potential for a compact and cost efficient experimental setup. This shall be used for an accurate characterization of the gas jet, probing simultaneously its density and velocity. Laboratory experiments with different solid targets with varying reflectivity showed the possibility to measure velocities with better than 2% accuracy.

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