SourceLAB
Laser Plasma Technologies

SL-GT-10 Laser Plasma Gas Target

High-density fast-switching compact gas jet

- **High-density gas jet system (above n_c for near-IR laser wavelengths)**
- **Sub-millimetric jet size from stainless steel nozzles**
- **Customized and easy-to-tune output flow**
- **Open/close timescale within few ms**
- **Compatible with secondary vacuum pump assembly**

The SL-GT-10 system, originally developed at Laboratoire d'Optique Appliquée, is a high-pressure fast-switching gas jet assembly conceived for the interaction between a high-intensity laser and a gaseous target at very high density (above the critical density n_c for a near-infrared laser wavelength). This system can be used for plasma microscopy in the near-critical regime, and high-energy particle or radiation generation, such as coherent XUV pulses, electron or ion beam acceleration.

➢ Design and hardware

The SL-GT 10 is designed to enable a localized interaction length, below 1 mm, along with an efficient coupling between the intense laser pulse and the plasma. To this end, the stainless steel nozzle delivering the jet has a sub-millimetric exit diameter (typically 400 µm), that shape the gas flow for obtaining the appropriate Mach number M, and the backing pressure can be set up to 350 bar. Thanks to the fast-switching valve specially developed for laser-plasma experimental conditions, the system is also compatible for safe operations with a standard turbo-pumping assembly ($<10^{-3}$ mbar).

The SL-GT 10 system comprises mainly:
- A pneumatic air-driven pressure booster, compressing the inlet pressure from typically 50 bar (supplied by standard gas cylinder) to an outlet pressure of more than 300 bar. The booster is adapted for pulsed operations requiring moderate gas throughput.
- An analog/digital air controller (0-10 bar) for setting the booster working point.
- A special rapid reaction valve, working with a pressure ratio inlet/outlet above 30. The valve open and close with a rotating stainless steel ball ensuring fast-switching and long-term operation (above 1 billion oscillations).
- A high-amp power supply (11A, 32V) to trigger the valve.
- One sub-millimetric nozzle shaping the gas flow. Optimized microjets designed for the SL-GT-10 system cover the range from subsonic (M<1) to supersonic (M≈6) flows.
- High-pressure pipes and connectors, including quick connectors for easy coupling/decoupling of the valve to the high-pressure line (tested up to 350 bar).

Examples of applications
Particle acceleration
Plasma microscopy
Coherent XUV amplification

Performances

The SL-GT-10 system offers stable and shot-to-shot reproducible conditions to explore the near-critical regime of interaction with a near-IR laser beam (e.g. a Ti:Sapphire laser system at λ_0=800 nm). The system can be used with various rare gases (He, Ar, Ne) and gaseous mixtures of these gases. Different millimetric and sub-millimetric nozzle types can be installed. The typical atomic peak density at the exit of a sub-millimetric nozzle is close to 2 x 10^{21} atoms/cm^3 (see Fig. 1).

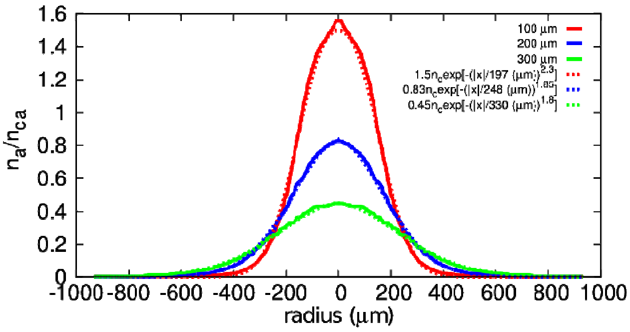

Fig. 1: Neutral He profiles n_a normalized to the atomic critical density n_{ca} at 100 (red line), 200 (blue line), and 300 μm above a 400 μm sonic nozzle from Abel-inversion. The dotted lines indicate best exponential fits (ref: F. Sylla et al, RSI (2012)).

The versatility of the SL-GT-10 system enables the experimentalist to produce flows of various Mach numbers (from subsonic M<1 to supersonic M>>1 flows), and gradient scale lengths over a ten-fold range (from 100 µm to 1 mm). It is particularly adapted to study parametrically laser pulse propagation conditions and energy coupling (see Fig. 2) via optical diagnostics (plasma microscopy).

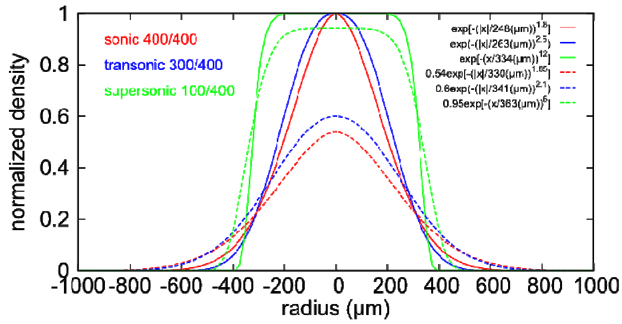

Fig. 2 : Sonic (red), transonic (blue), and supersonic (green) flows (best fits) for three nozzles of throat diameters 400, 300, and 100 μm respectively (same exit diameters of 400 μm). The curves are normalized to the peak density at 200 μm. The solid and dashed lines correspond to profiles at 200 and 300 μm from the exit, respectively. Both vertical and radial gradients become larger as the sonicity (Mach number) decreases (ref: F. Sylla et al, RSI (2012)).

Scientific publications

- F. Sylla et al, **Phys. Rev. Lett.,** 110, 085001 (2013)
- F. Sylla et al, **Phys. Rev. Lett.,** 108, 115003 (2012)
- F. Sylla et al, **Rev. Sci. Instr.,** 83, 033507 (2012)

Technical data

Jet performances	
Atomic peak density (with a 400 µm-cylindrical nozzle exit)	> 2x10^{21} atoms/cm^3 (helium, argon, neon)
Mach number (with a sub-millimetric nozzle)	Up to 6
Gradient scale length (with a 400 µm-cylindrical nozzle exit)	< 400 µm
Repetition rate	1 Hz (with a pumping capacity of 2500 sccm of N_2)
Open/close time	15 ms / < 40 ms
Compatible nozzle type	Min. 100 µm of critical diameter
Valve	
Valve dimensions (L x r)/mass	90 x 34 (mm x mm) /1.5kg
Valve pressure limit	Max. 700 bar
Valve open/close timescale	< 3 ms
Air-driven booster	
Inlet pressure	Min. 30 bar
Outlet pressure	Max. 400 bar
Digital control	Yes (in option)
High-pressure pipes	
Length	Up to 3 m (flexible)
pressure	Max. 344 bar