

Short-pulsed Nd:YAG-laser interaction with tin micro-droplets

Oscar O. Versolato
EUV Plasma Processes
Advanced Research Center for Nanolithography



ARC NL

The Advanced Research Center for Nanolithography (ARCNL)

MISSION

The research of ARCNL focuses on the **fundamental physics** that is involved in or related to current and future technologies that are or will be employed in the context of lithography and nanolithography, primarily for the semiconductor industry.

PARTNERS

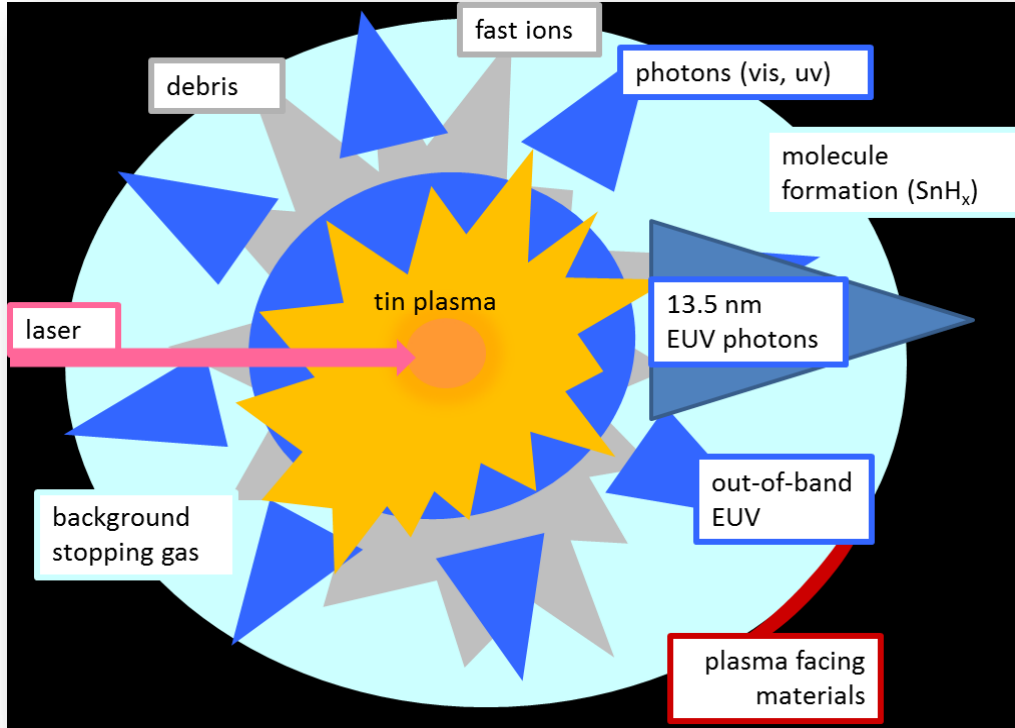
Foundation for Fundamental Research on Matter (FOM/NWO), University of Amsterdam, VU University Amsterdam, ASML

LOCATION

Amsterdam Science Park

EUV Plasma Processes

Fundamental physics questions in plasma EUV sources



- radiation-hydrodynamics

- atomic structure

A. Windberger et al., Phys. Rev. A **94**, 012506 (2016)

F. Torretti et al, Phys. Rev. A **95**, 042503 (2017)

J. Scheers et al, in preparation

F. Torretti et al, in preparation

- electron recombination (DR)

- fluid dynamics

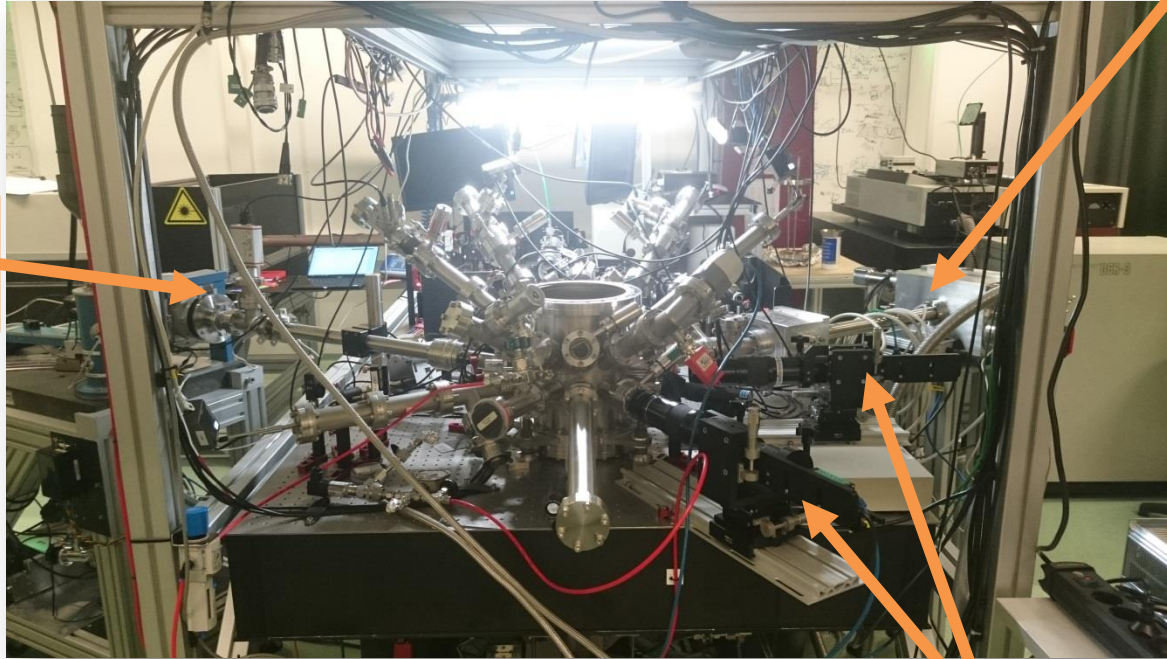
- ion-surface interactions

- ion-molecule collisions

Droplet generator setup at ARCNL

UT transmission spectrometer

Rowland circle
EUV spectrometer



“front” view and side view shadowgraphy

Acknowledgements

ARCNL EUV PP team:

Jim Visschers (MSc)
Sjoerd van der Heijden (Msc)
Dmitry Kurilovich (PhD)
Francesco Torretti (PhD)
Joris Scheers (PhD)
Ruben Schupp (PhD)
Mart Johan Deuzeman (PhD)
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Alexander Windberger (postdoc)
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ARCNL is a public-private partnership between FOM, UvA, VU and ASML

ARCNL EUV G&I team:

Tiago de Faria Pinto (PhD)
Randy Meijer (PhD)
Aneta Stodolna (postdoc)
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Kjeld Eikema (group leader)

ASML team

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Andrei Yakunin
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Alexandr Bratchenia
Wim van der Zande
Jayson Stewart
Andrew Laforge
Igor Fomenkov ... a.o.

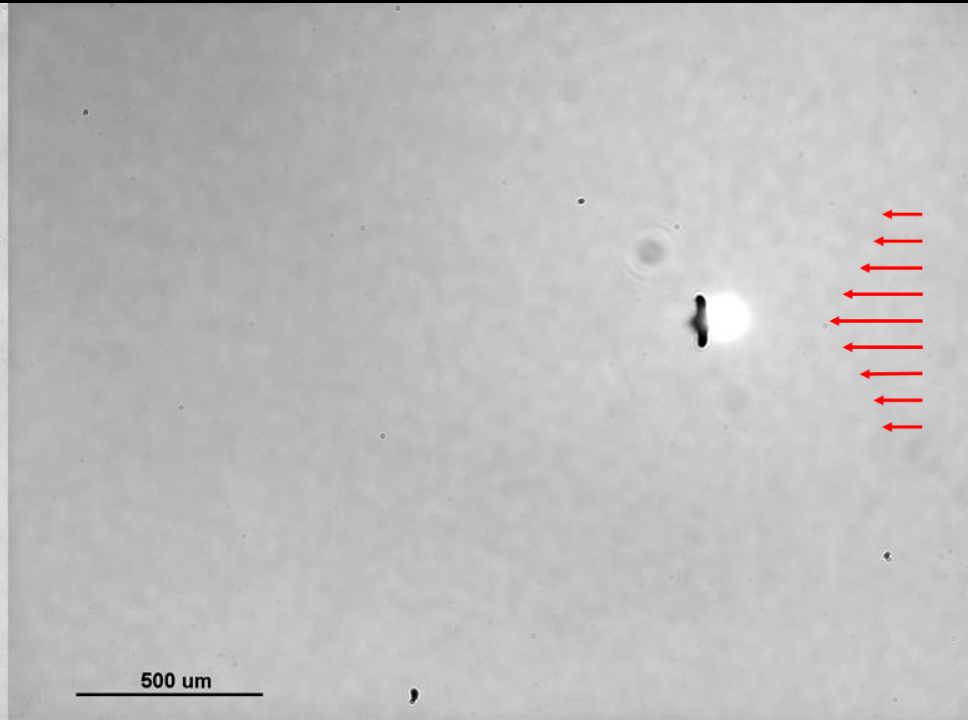
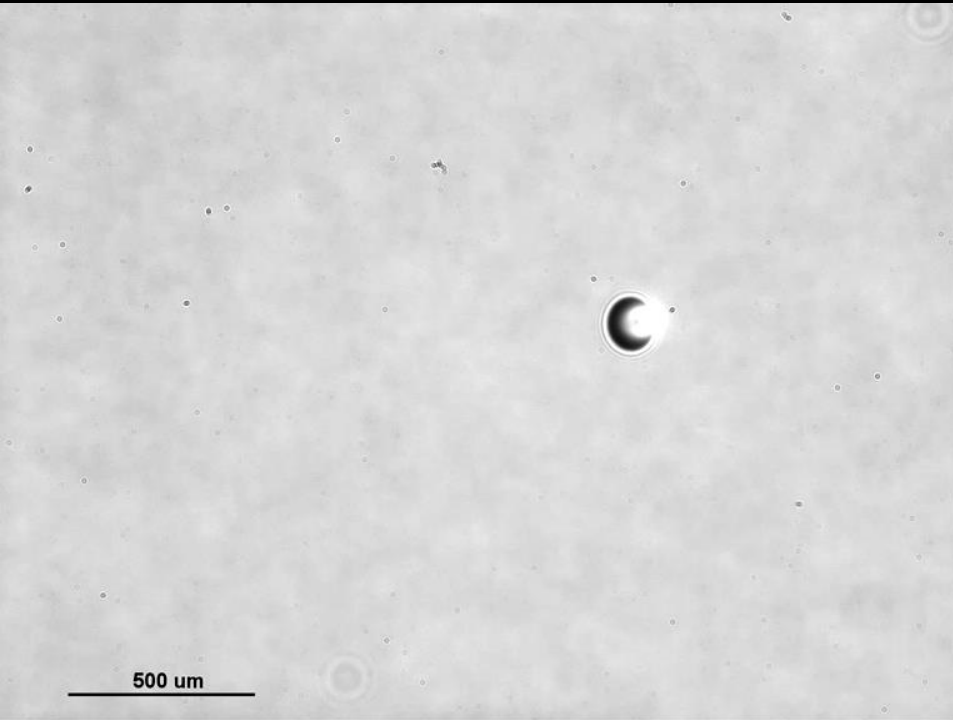
Collaborators:

H. Gelderblom (University of Twente)
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J.R. Crespo López-Urrutia (MPIK)
H. Bekker (MPIK)
S. Dobrodey (MPIK)
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D. Kim (ISAN)
E. Eliav (School of Chemistry, Tel Aviv)
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J. Berengut (UNSW Australia)
E. Kahl (UNSW Australia)
Muharrem Bayraktar (University of Twente)
Fred Bijkerk (University of Twente)

l: nanosecond prepulse

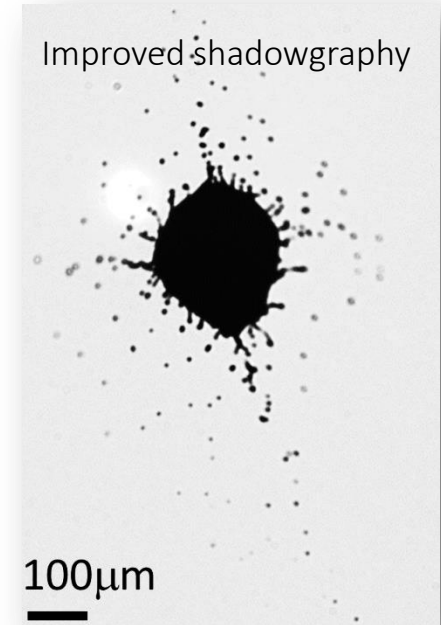
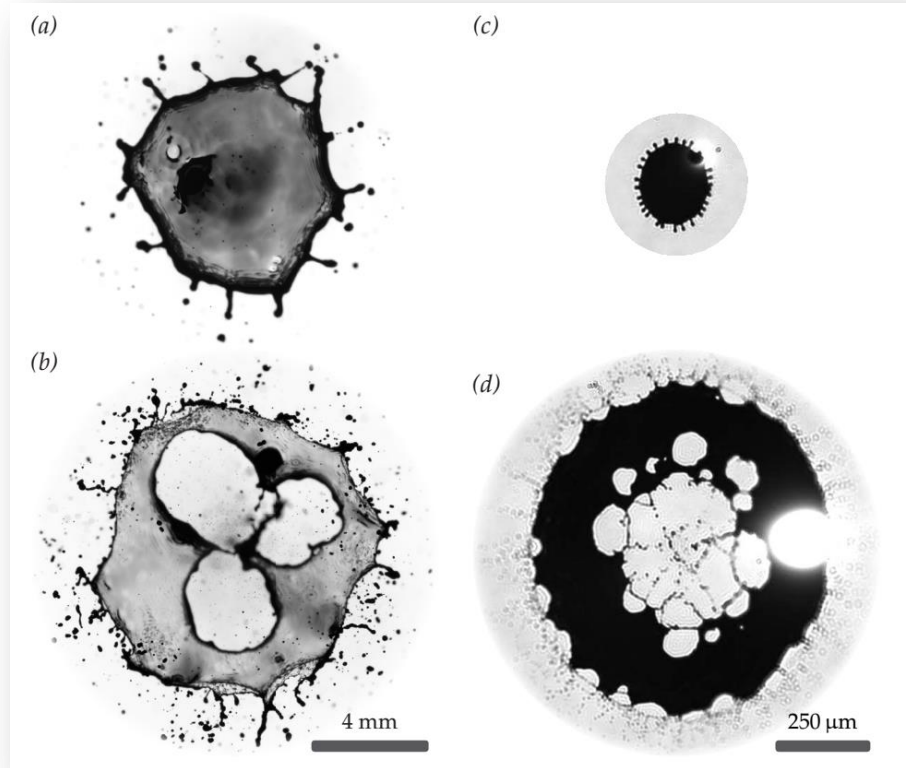
ns-pulse-driven droplet propulsion

Sensitive probe for plasma pressure scaling



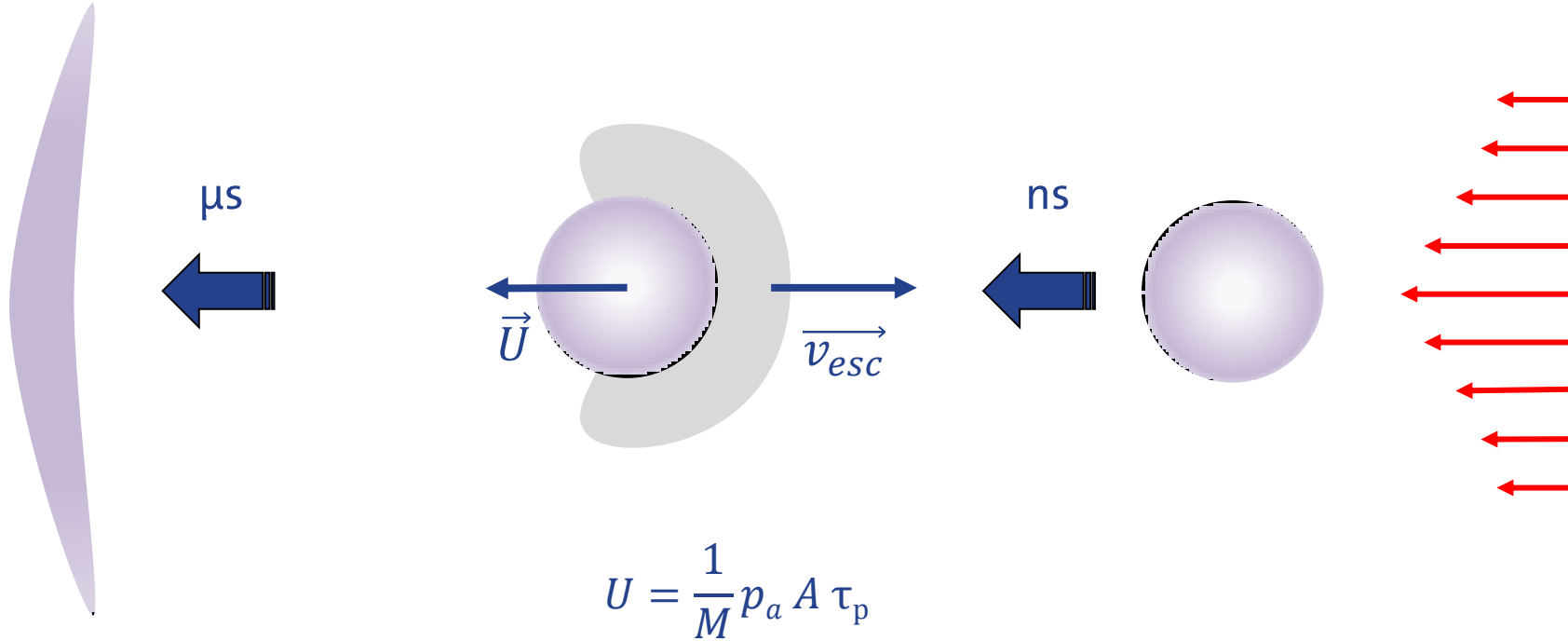
ligamentation and hole formation

Correspondences mm-sized water and um-sized tin drops



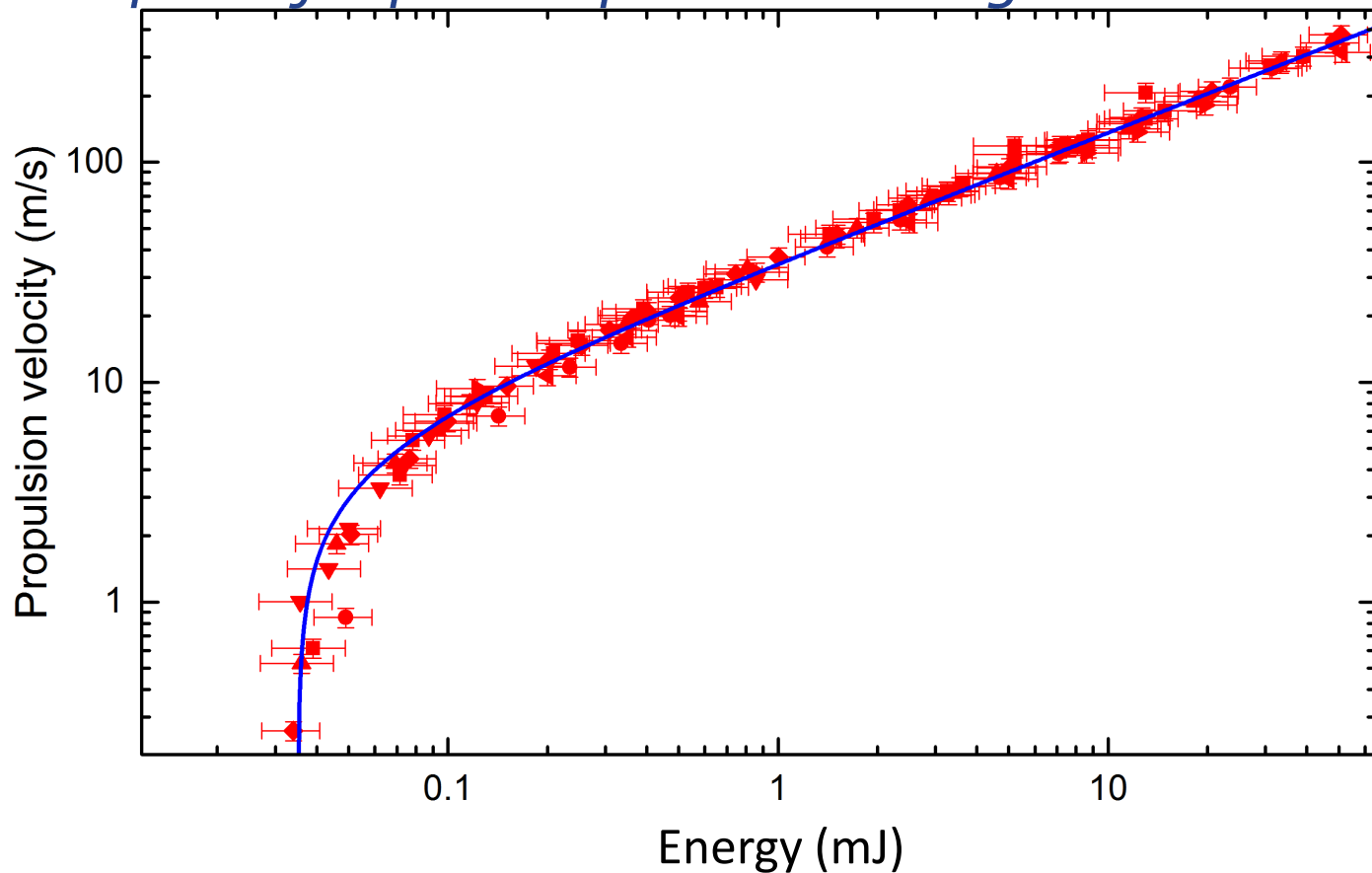
ns-pulse-driven droplet propulsion

Sensitive probe for plasma pressure scaling



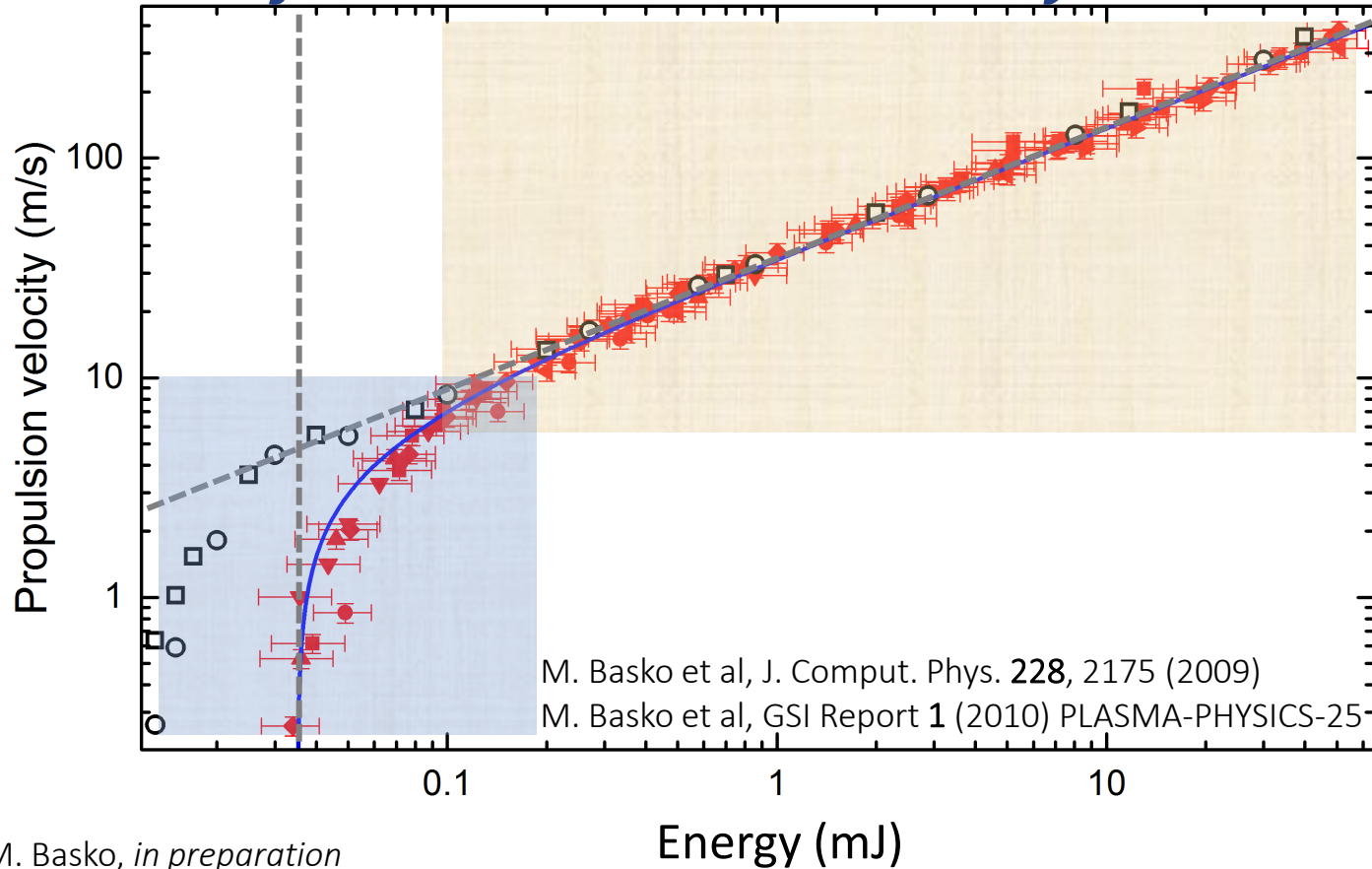
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Sensitive probe for plasma pressure scaling



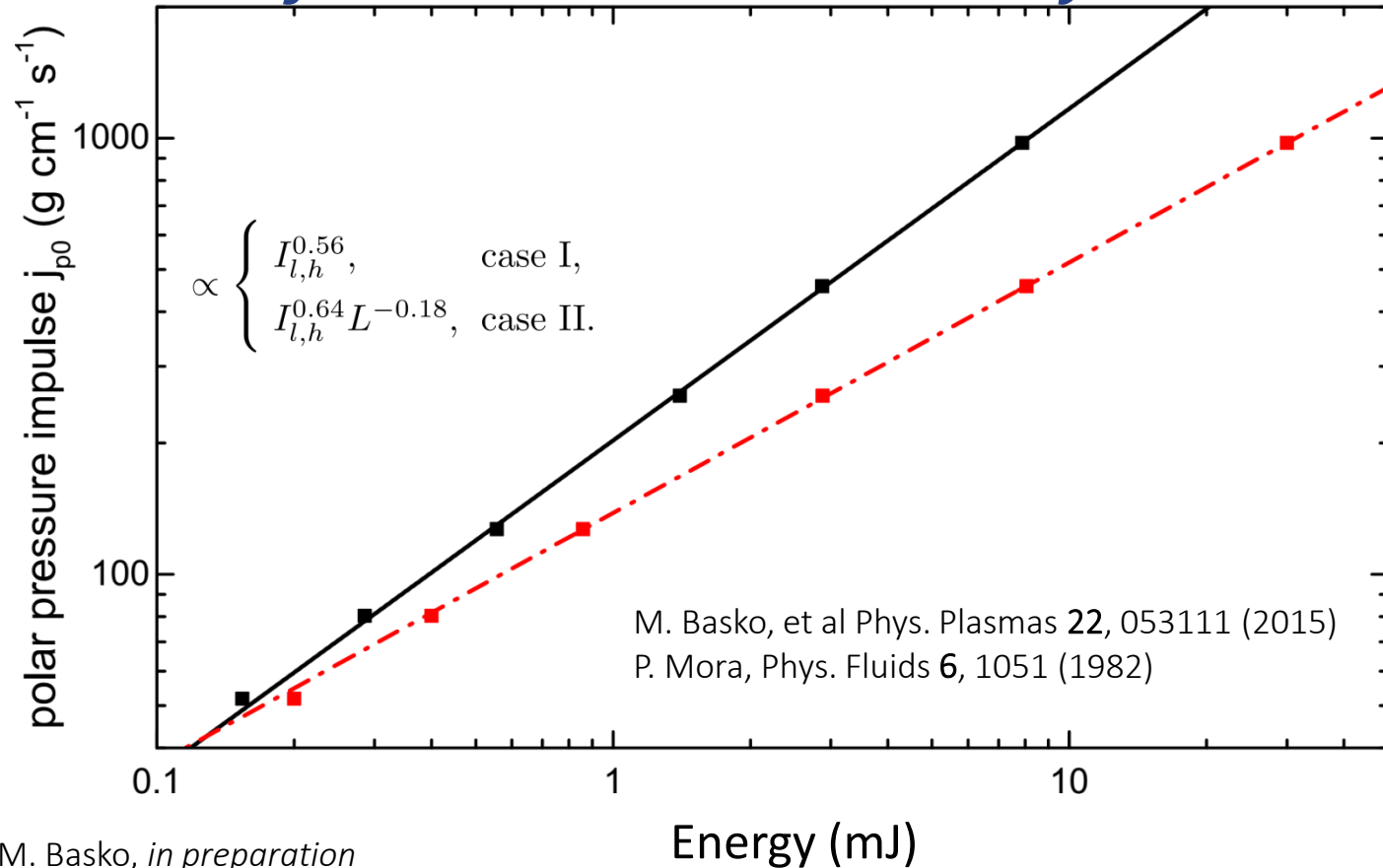
ns-pulse-driven droplet propulsion

Sensitive test of RALEF simulation and theory



ns-pulse-driven droplet propulsion

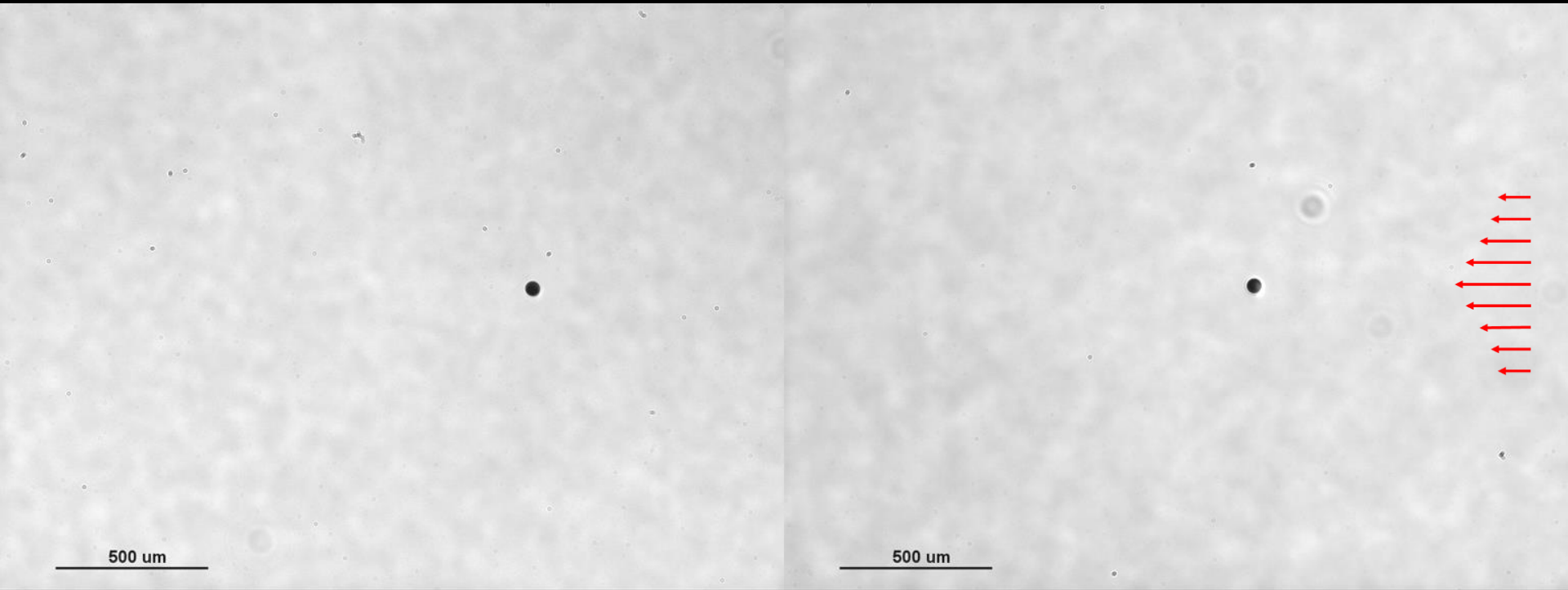
Sensitive test of RALEF simulation and theory



II: picosecond prepulse

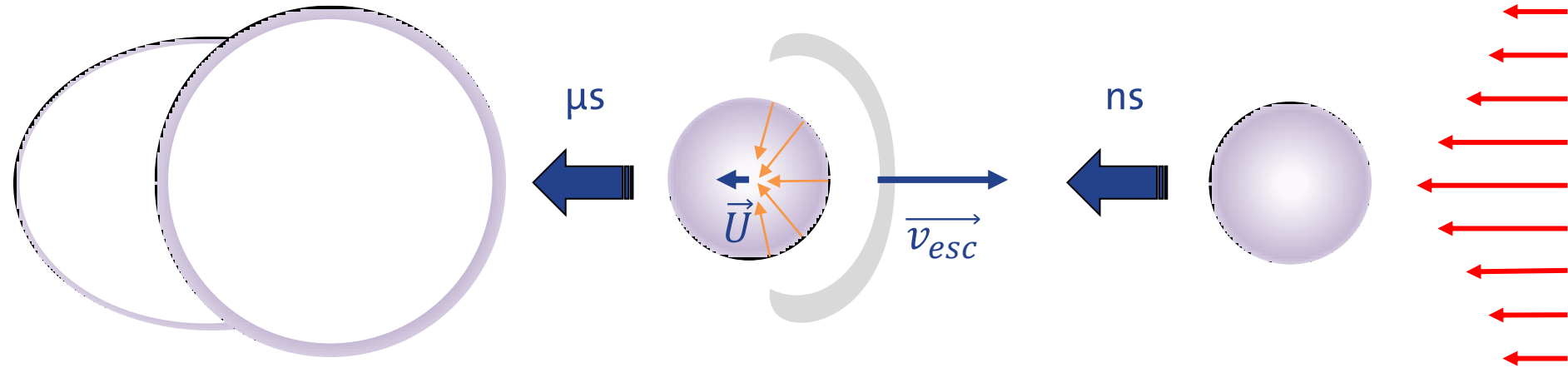
ps-pulse-driven droplet expansion

Cavitation and spallation from shockwaves



ps-pulse-driven droplet expansion

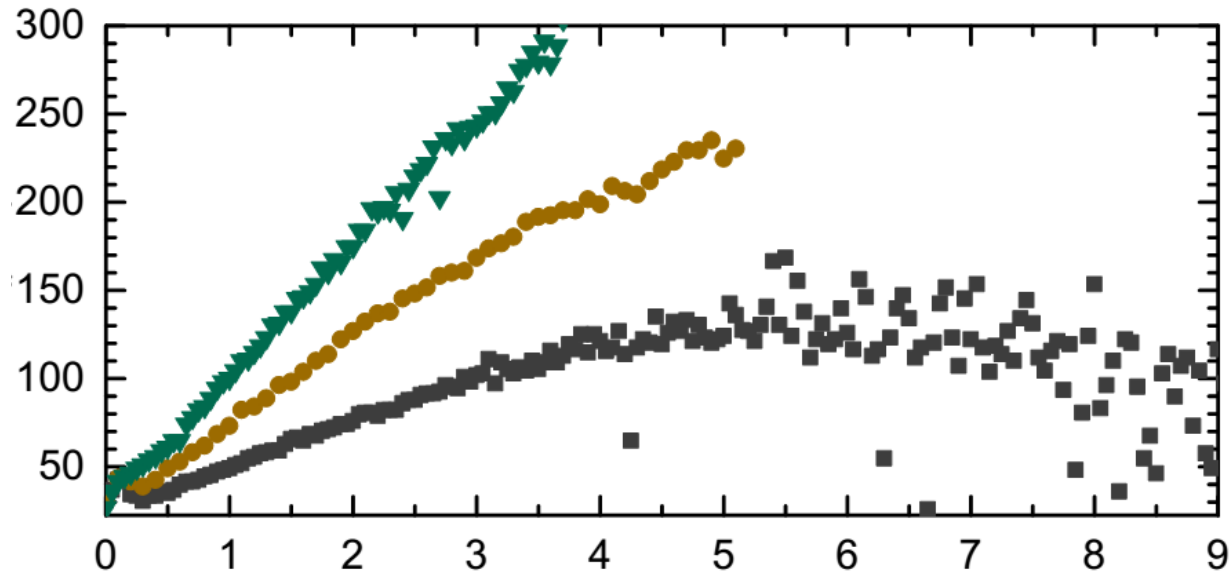
Cavitation and spallation from shockwaves



A. Y. Vinokhodov et al, Quant. Electr. **46**, 23 (2016)
M. M. Basko et al, Laser Phys. Lett. **14**, 036001 (2017)
M. Krivokorytov et al, Phys. Rev. E **95**, 031101 (2017)

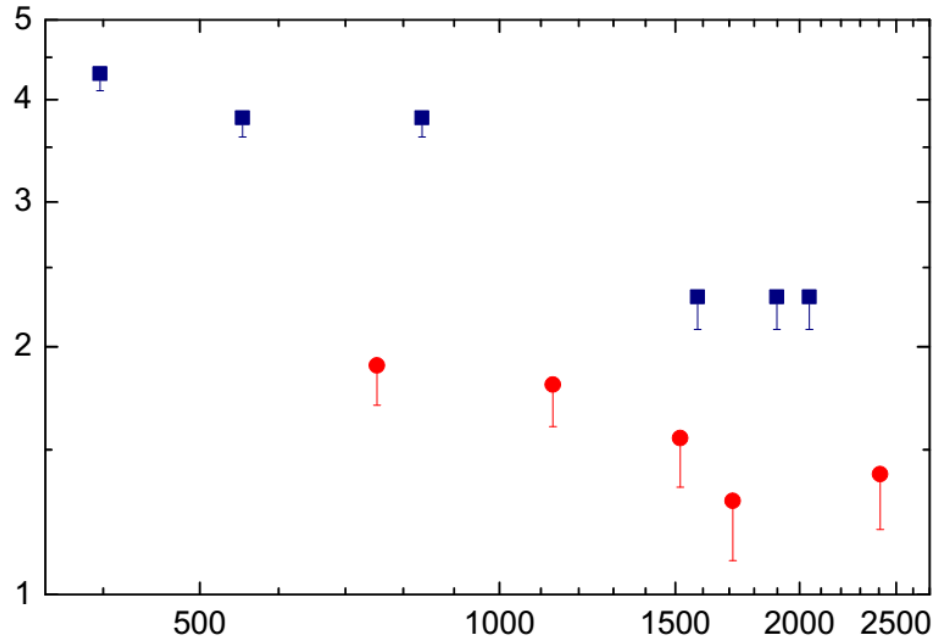
ps-pulse-driven droplet expansion

Capillary retraction of stretched spherical shell



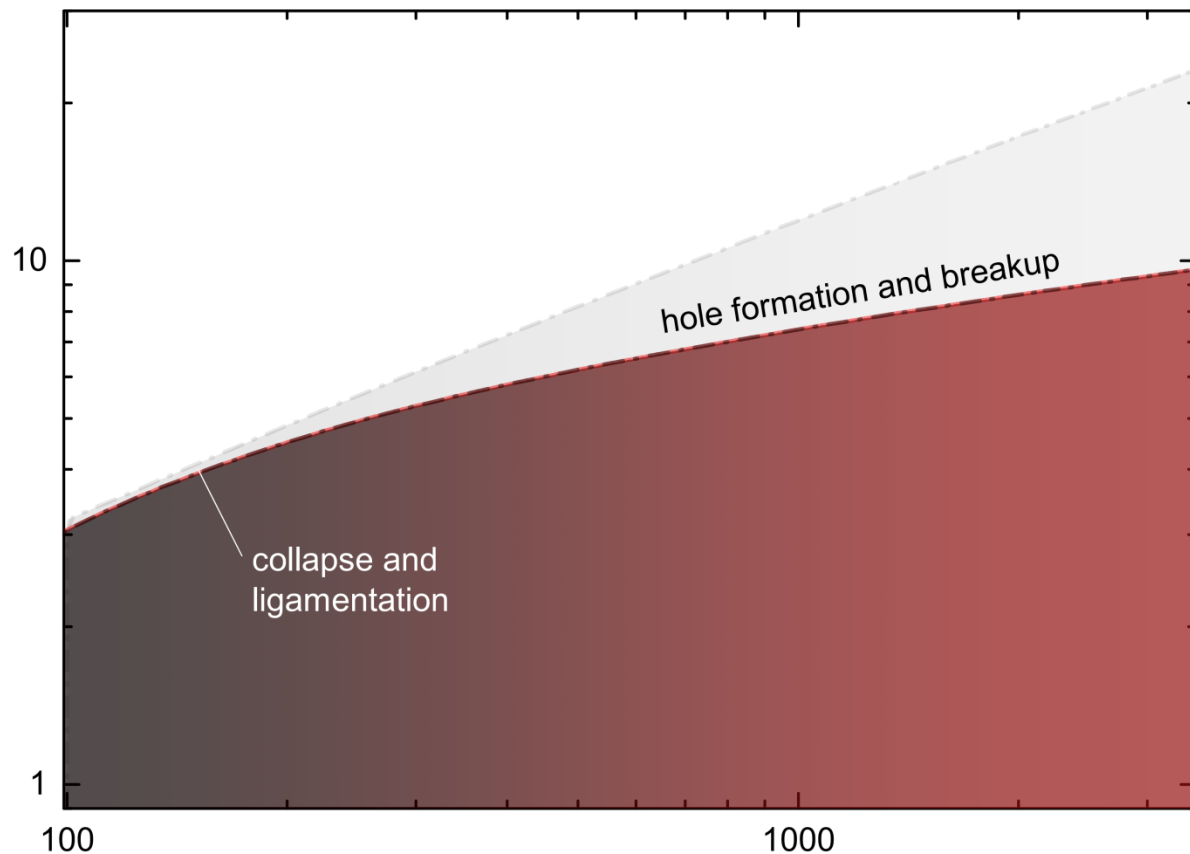
ps-pulse-driven droplet expansion

Time of first hole formation



ps-pulse-driven droplet expansion

Summary diagram



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