Scientific-Coordination Workshop on
Non-Ideal Plasma Physics (NPP-2021)
December 9-10, 2021, Moscow, Russia

Equations of state

and laser hydrodynamics/mechanics of deformable solids

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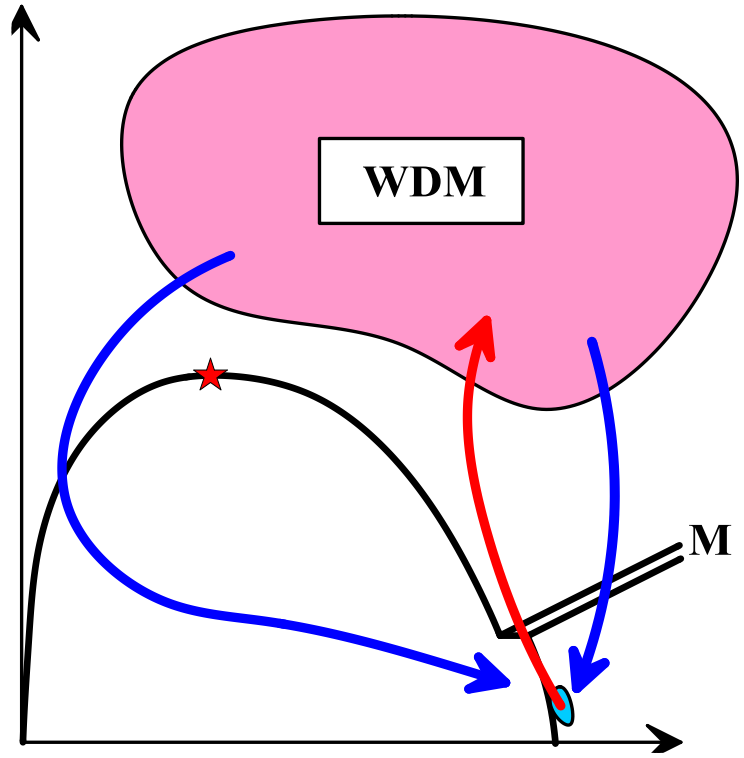
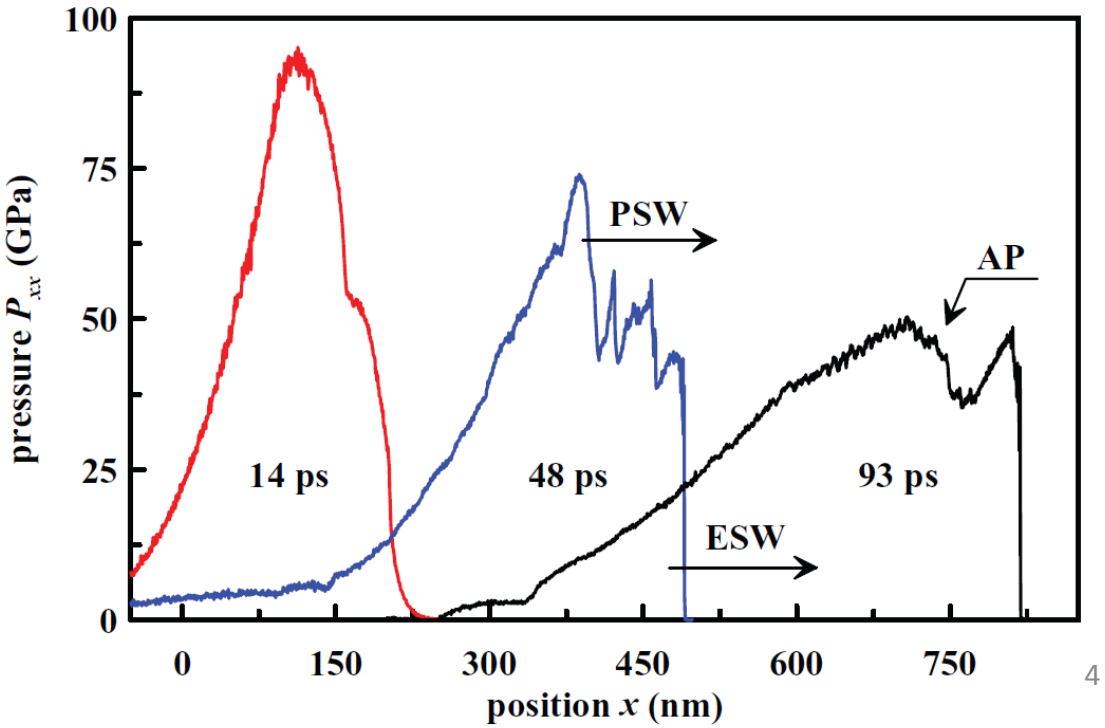
- In Russia, the main center for EoS developments are the JIHT + IPCP
- EoS are important because they link WDM and technologies



WDM:
Temperatures ~ 1 eV
Densities ~ condensed matter densities

areas/directions of active research = areas where better knowledge of EoS is required

- Better description is desirable for Supercritical region
- Today EoS are plastic. Thus elasticity is ignored. But elasticity changes Hugoniots! → HEL is high for laser generated shocks: 0.5 Mbar for Nickel



Demaske et al., PRB 87, 054109 (2013)

areas/directions of active research = TWO areas where better knowledge is required

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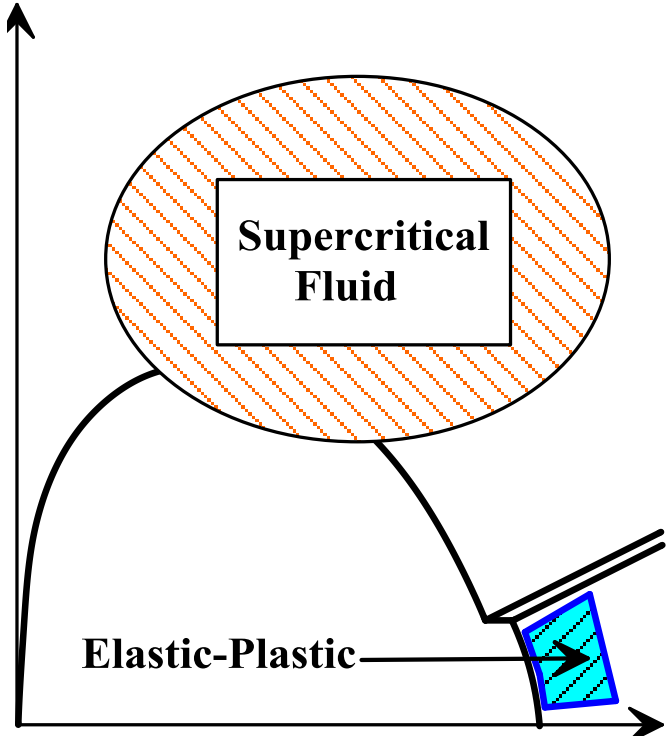
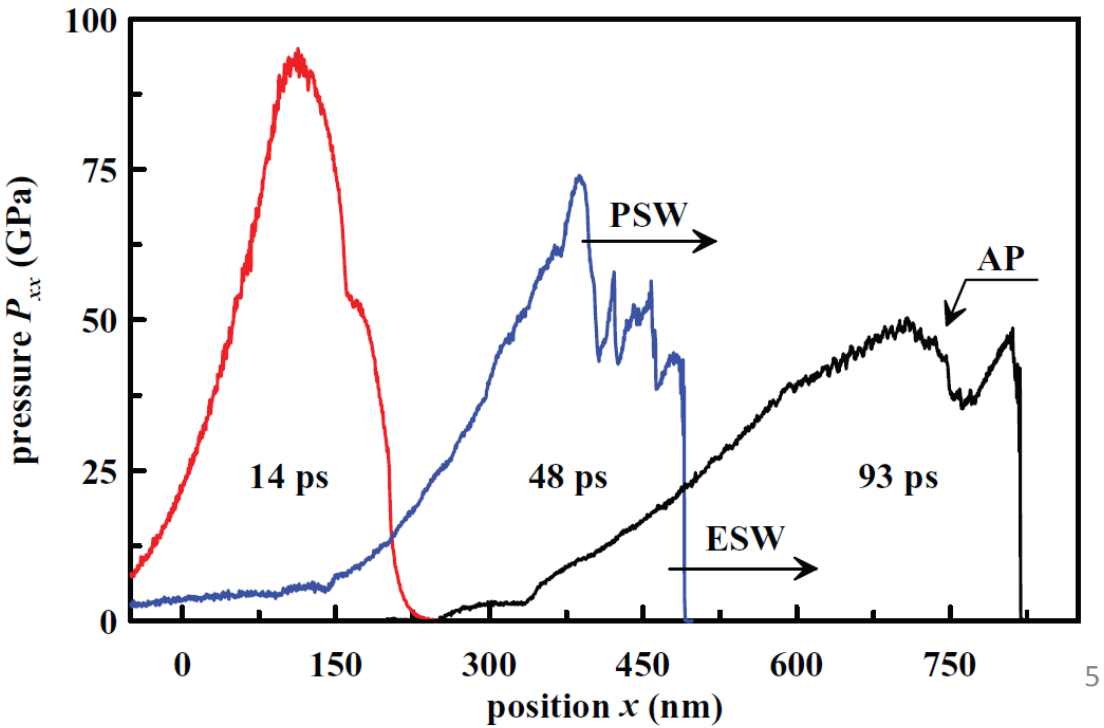
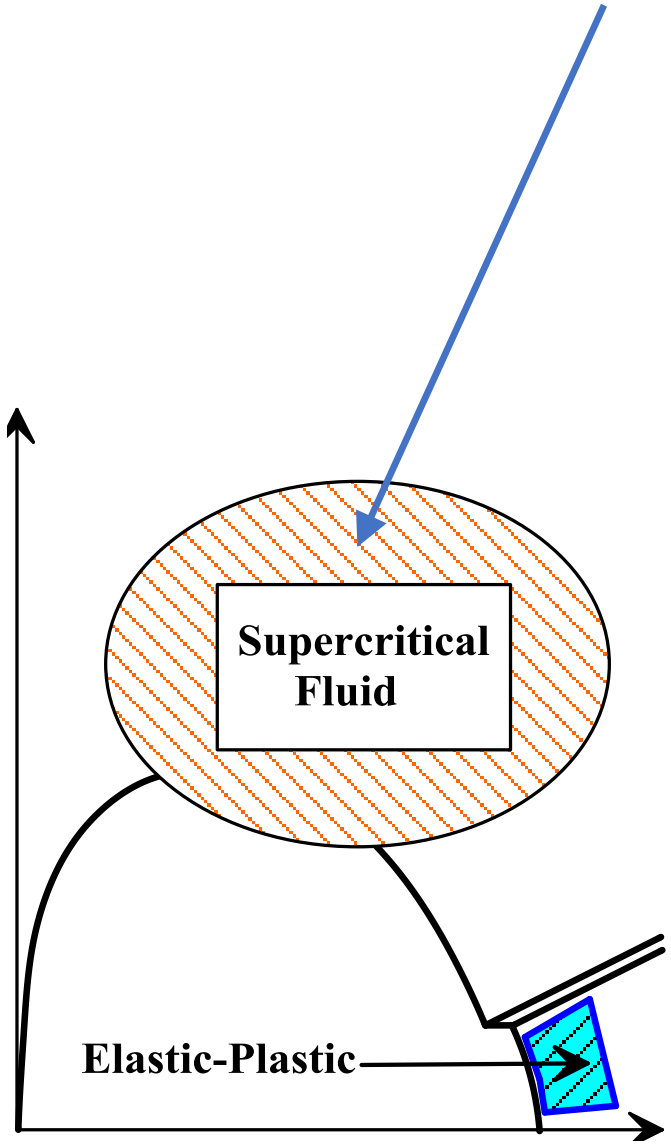
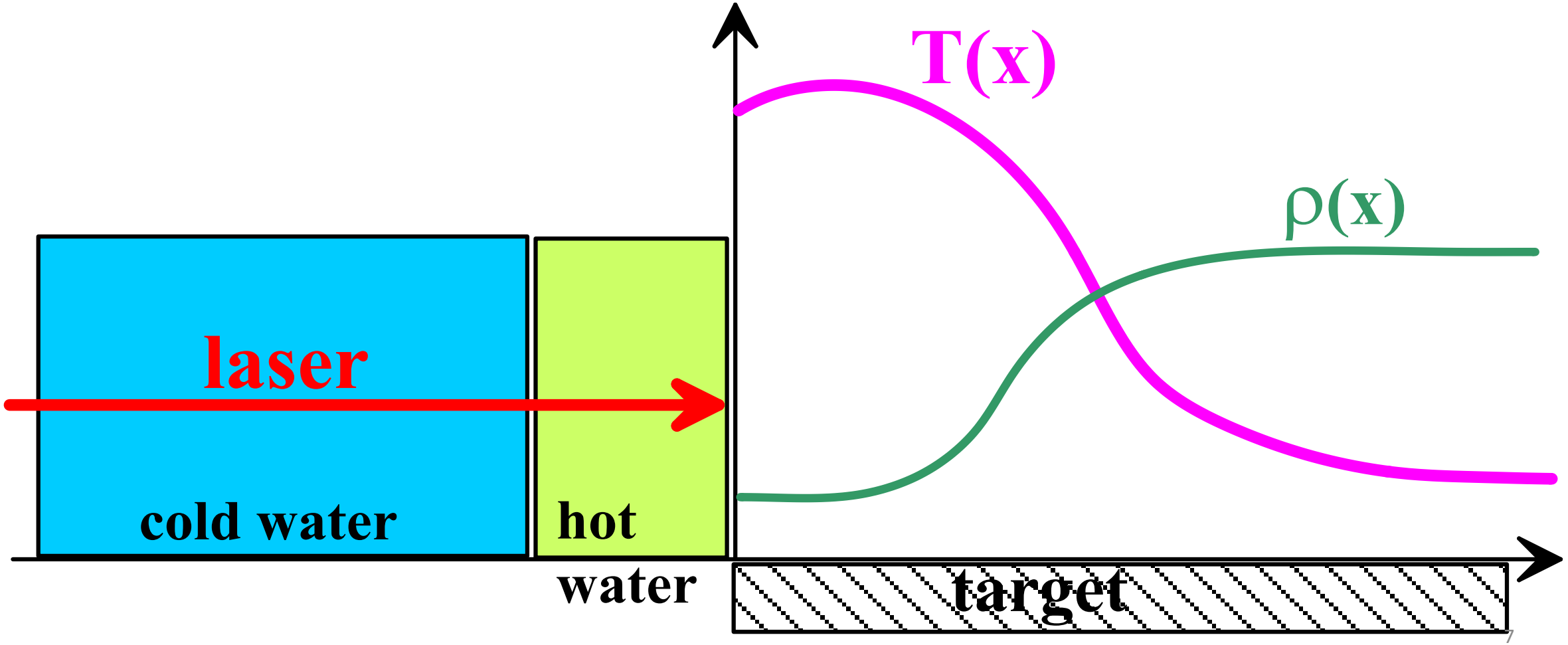




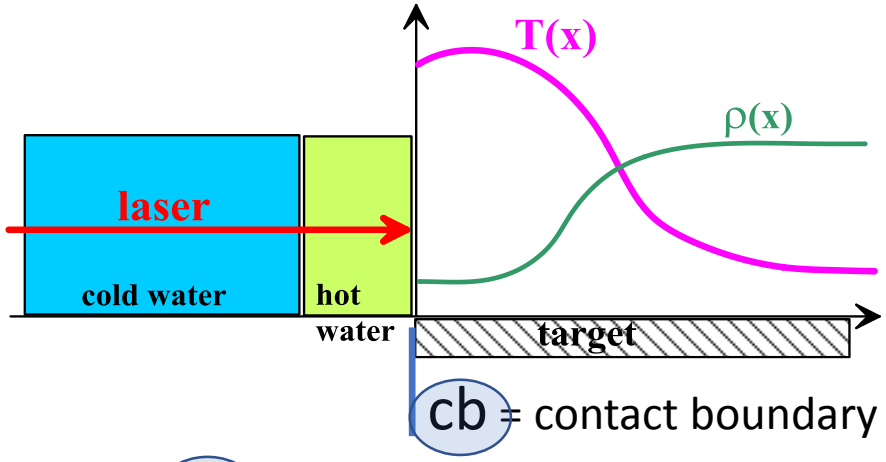
Example 1 = LAL =laser ablation in liquid



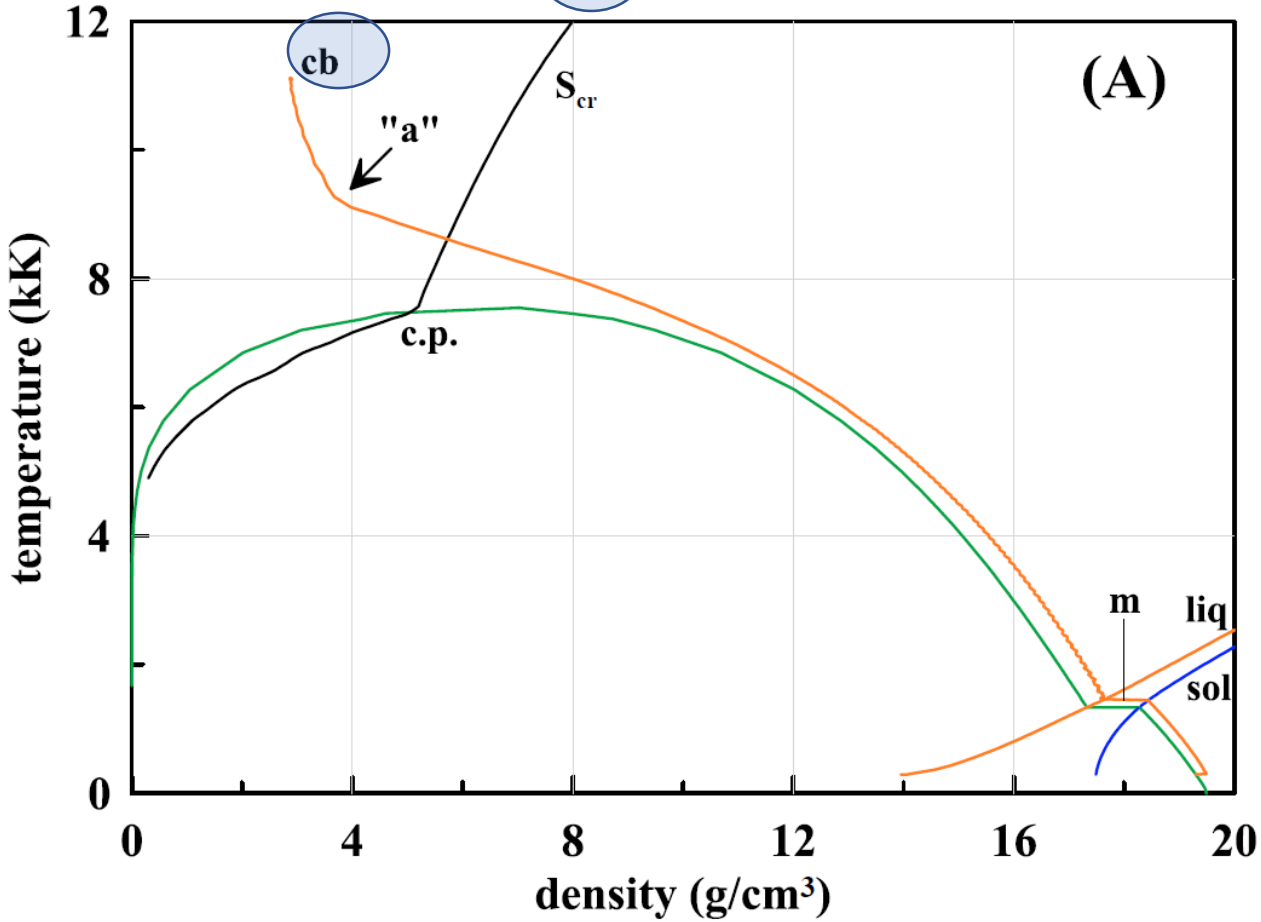
Laser ablation in liquid =LAL



Parametric presentation T(x), rho(x) → T(rho)



Inogamov et al., JETP Lett. (2022)



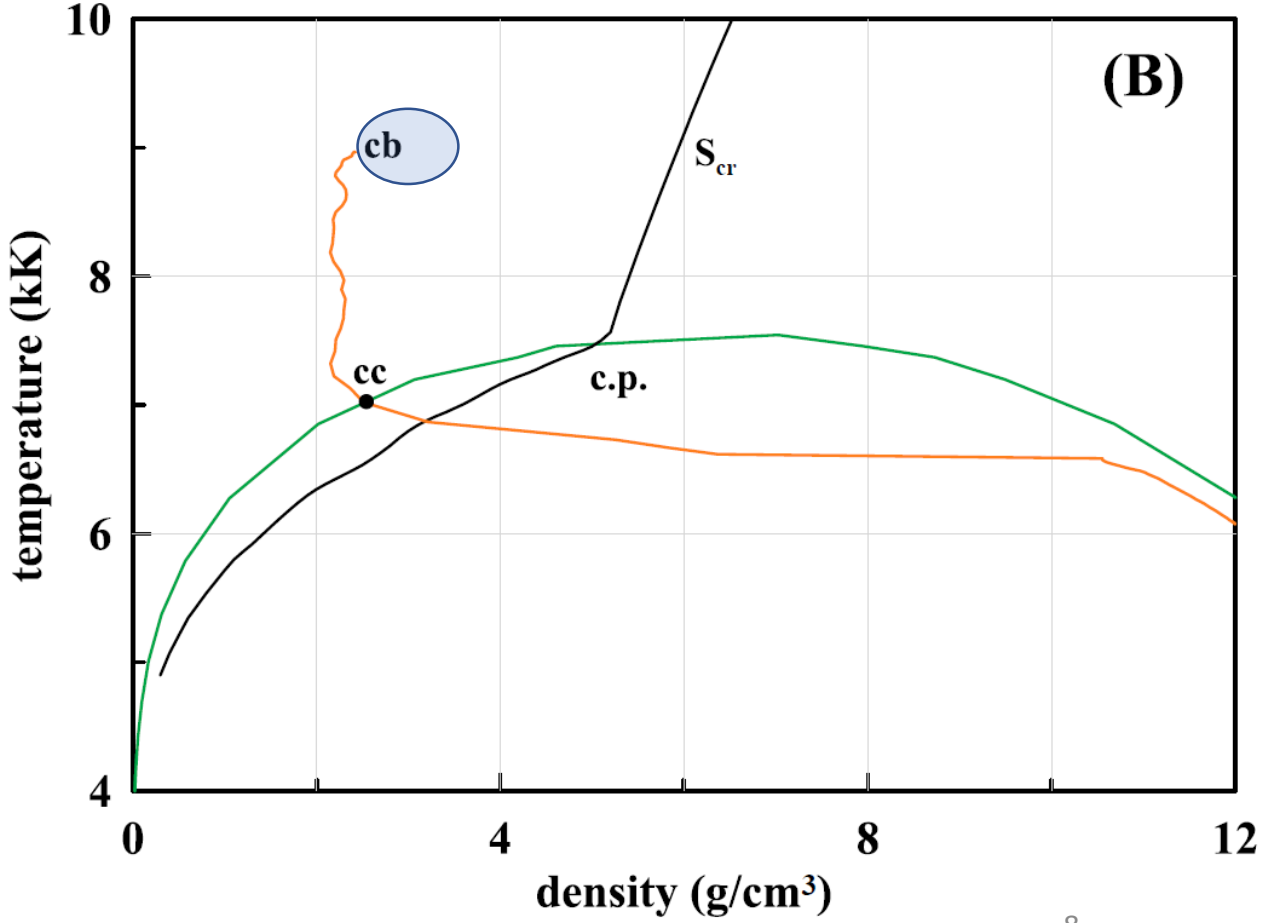
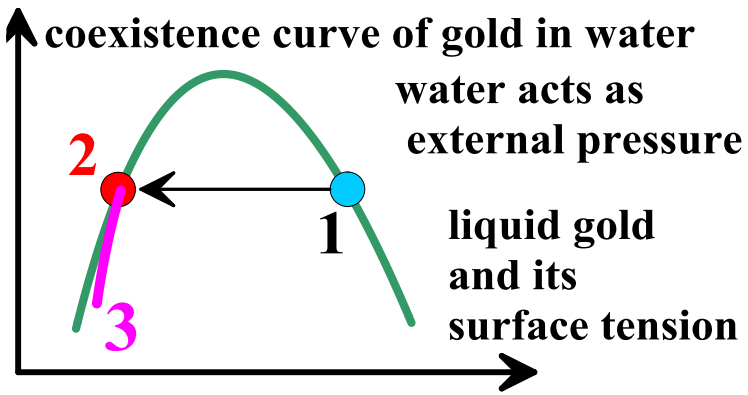


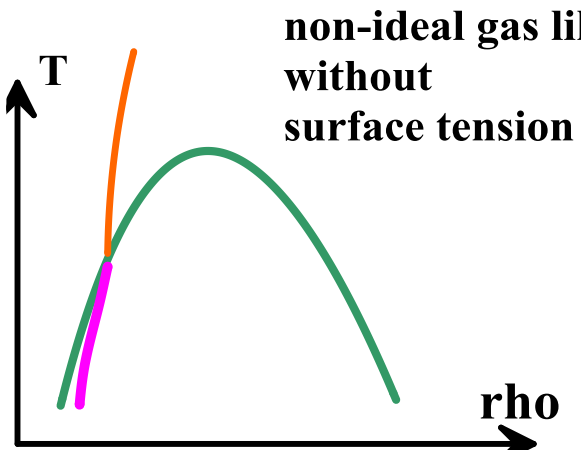
Рис. 2. Эволюция фазового состояния золота (A) $t = 0.3$ нс; (B) $t = 1$ нс. В процессе эволюции происходит

Supercriticality and vanishing of the surface barrier

- Surface tension is zero in supercritical fluid

- (2) evaporation → diffusion → cooling → condensation = formation of NPs
- diffusive interpenetration : metal vapor → hot liquid
- two regimes: **with evaporation/diffusion** and **without evaporation**!
- = **diffusion without evaporation** = **diffusive mixing**

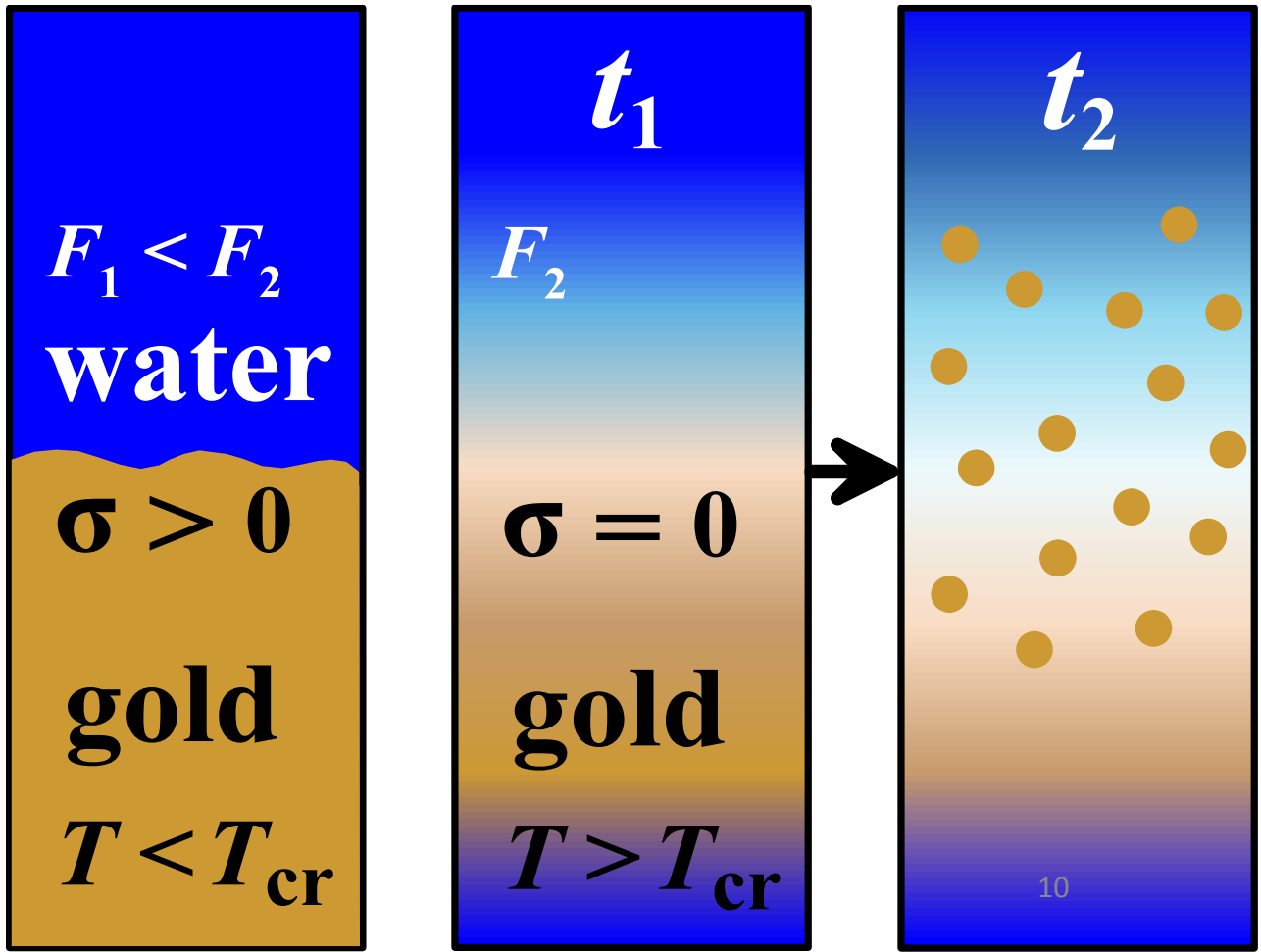


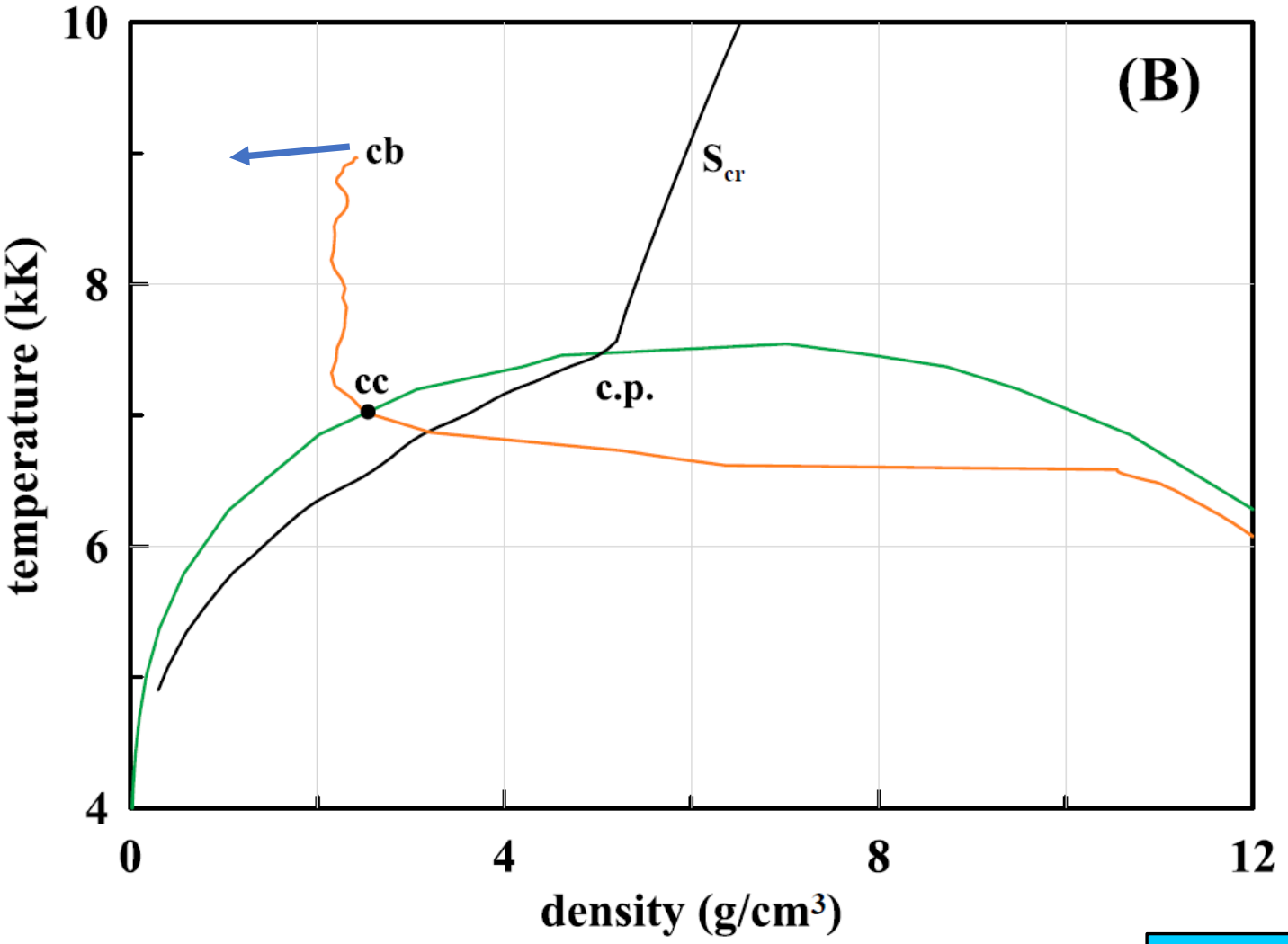


1-2 evaporation of gold in liquid

2-3 expansion of gold vapor inside liquid

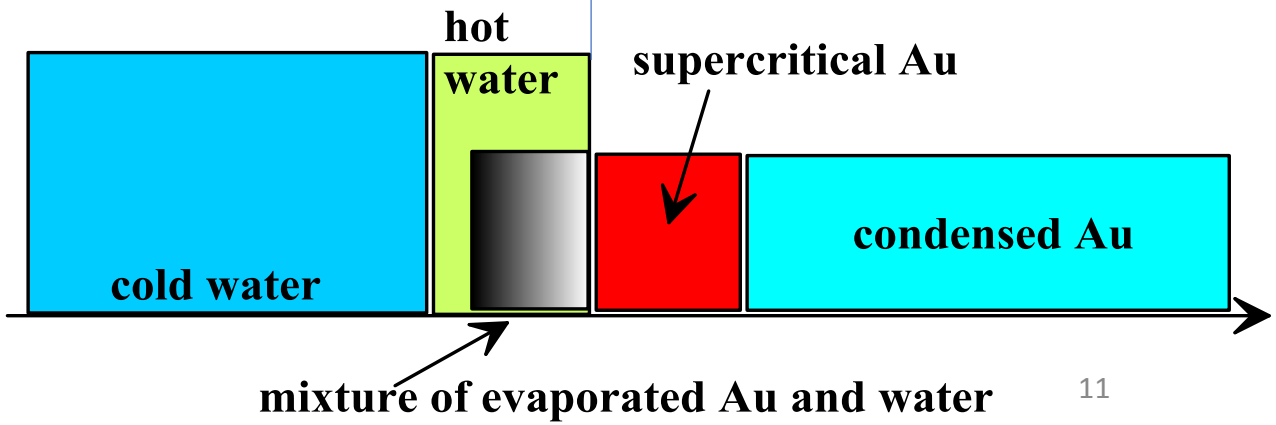
Au-liquid mixing without evaporation

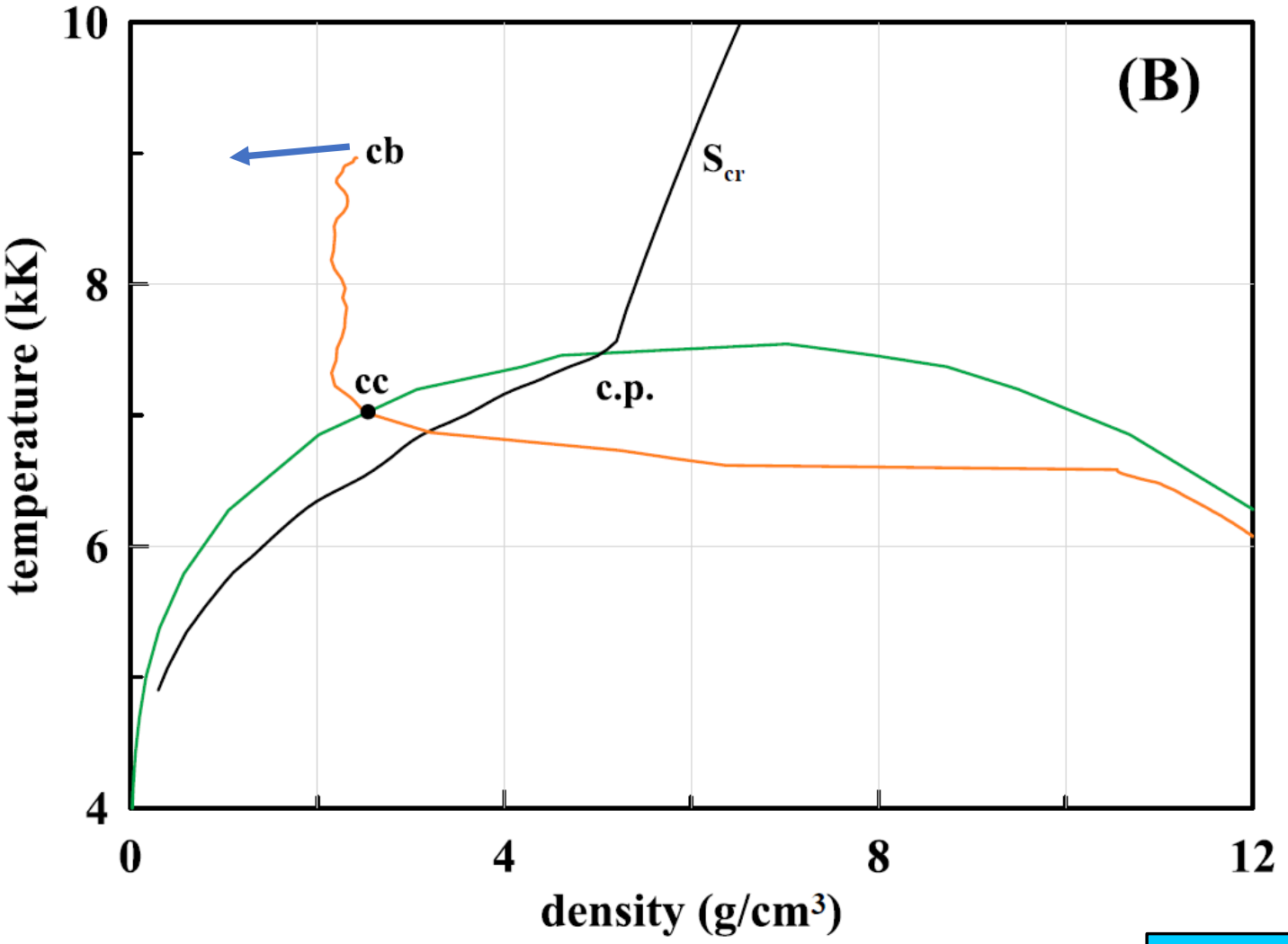




cc = condensation curve

cb = contact between Au and water





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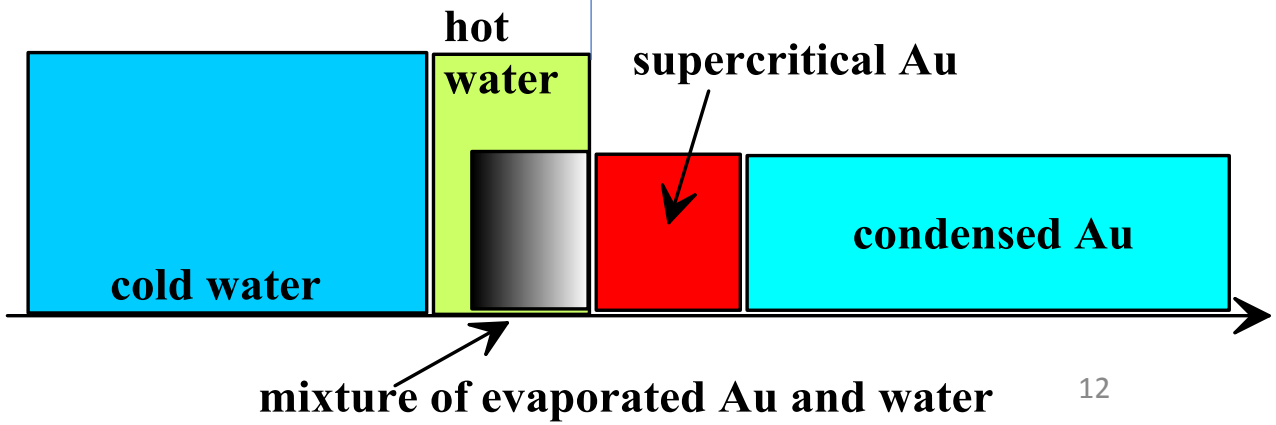

Hydrodynamics is arranged in such a way that gold, having passed the condensation curve, turns into a 2-phase mixture, which is compressed into a liquid. The compression is done by external pressure.

Only evaporated gold transfers into nanoparticles

LASER INITIATED SHOCK WAVE FROM PLASTIC PROPAGATION (RELATIVELY SIMPLE) TO PURELY ELASTIC REGIME WITH VERY COMPLICATED WAVE STRUCTURE

EXAMPLE 2

Elastic-plastic transformation

- Elastic-plastic laser shock leaves behind plastically modified matter and transits into pure elastic wave structure

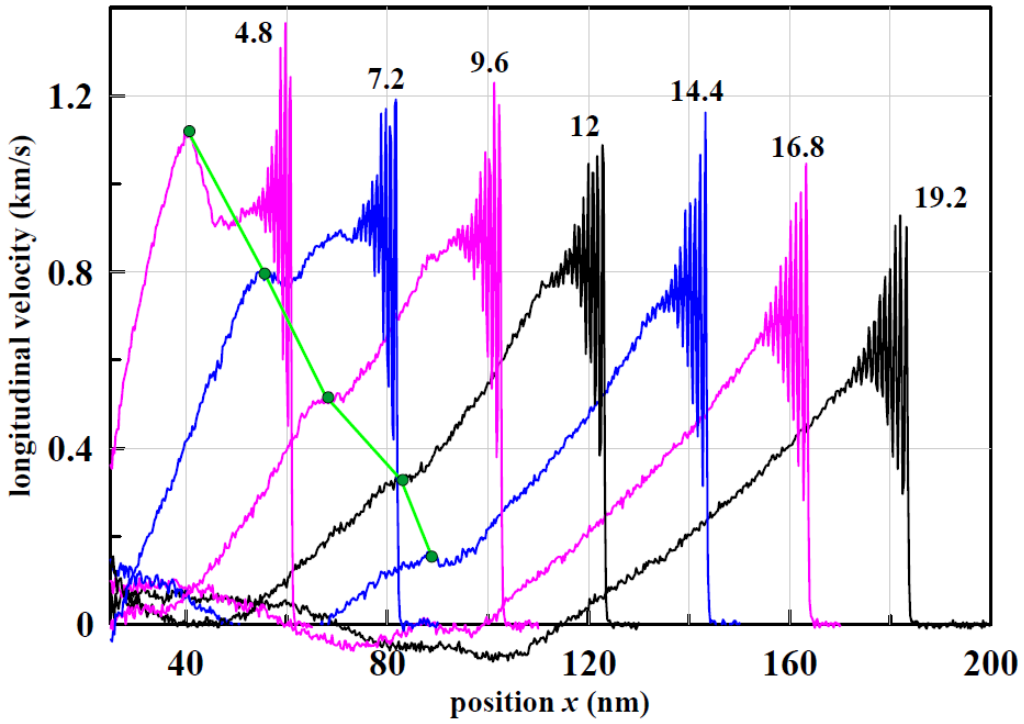

Рис. 5. Торможение и остановка фронта пластиче-

Inogamov et al., JETP Lett. (2022)

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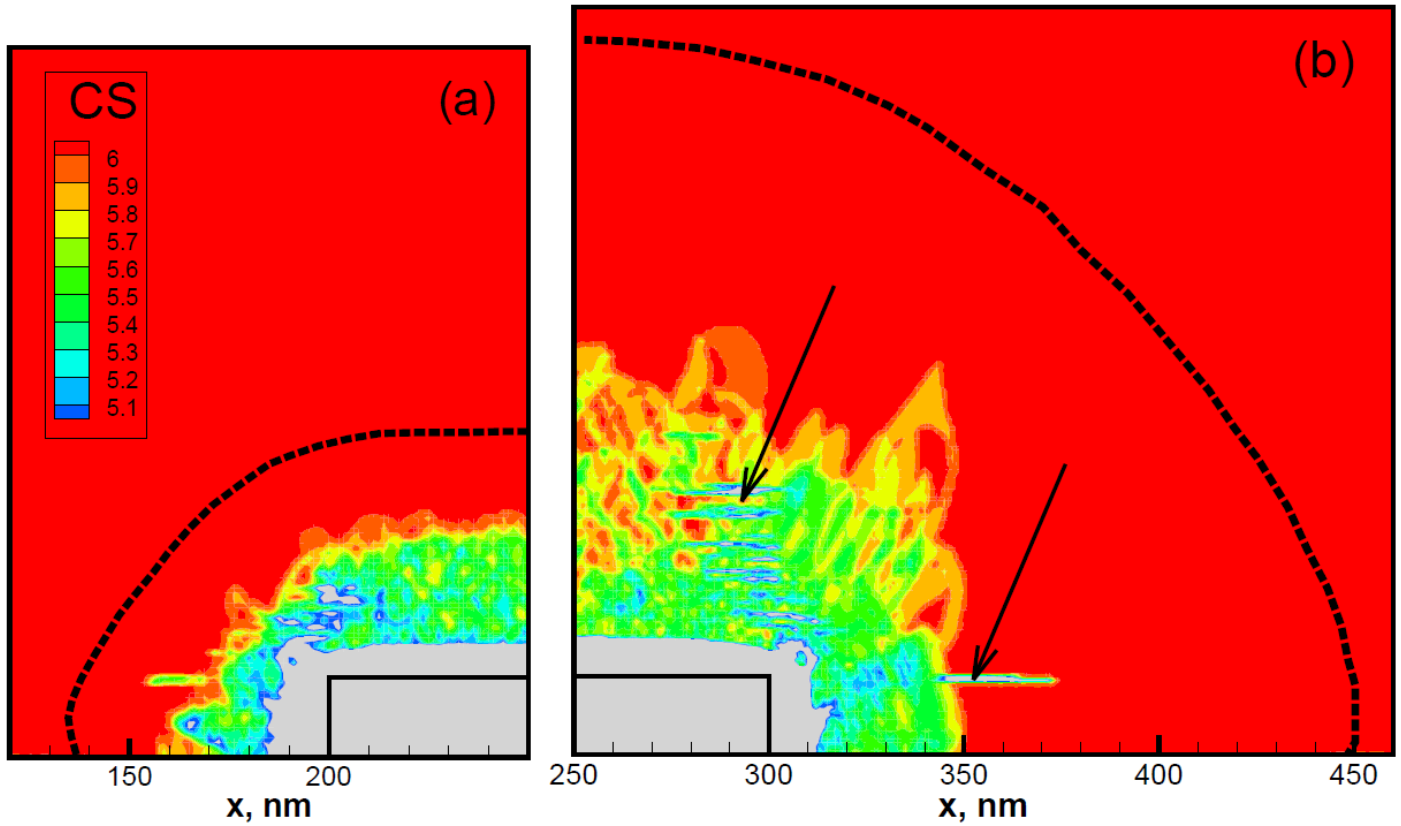
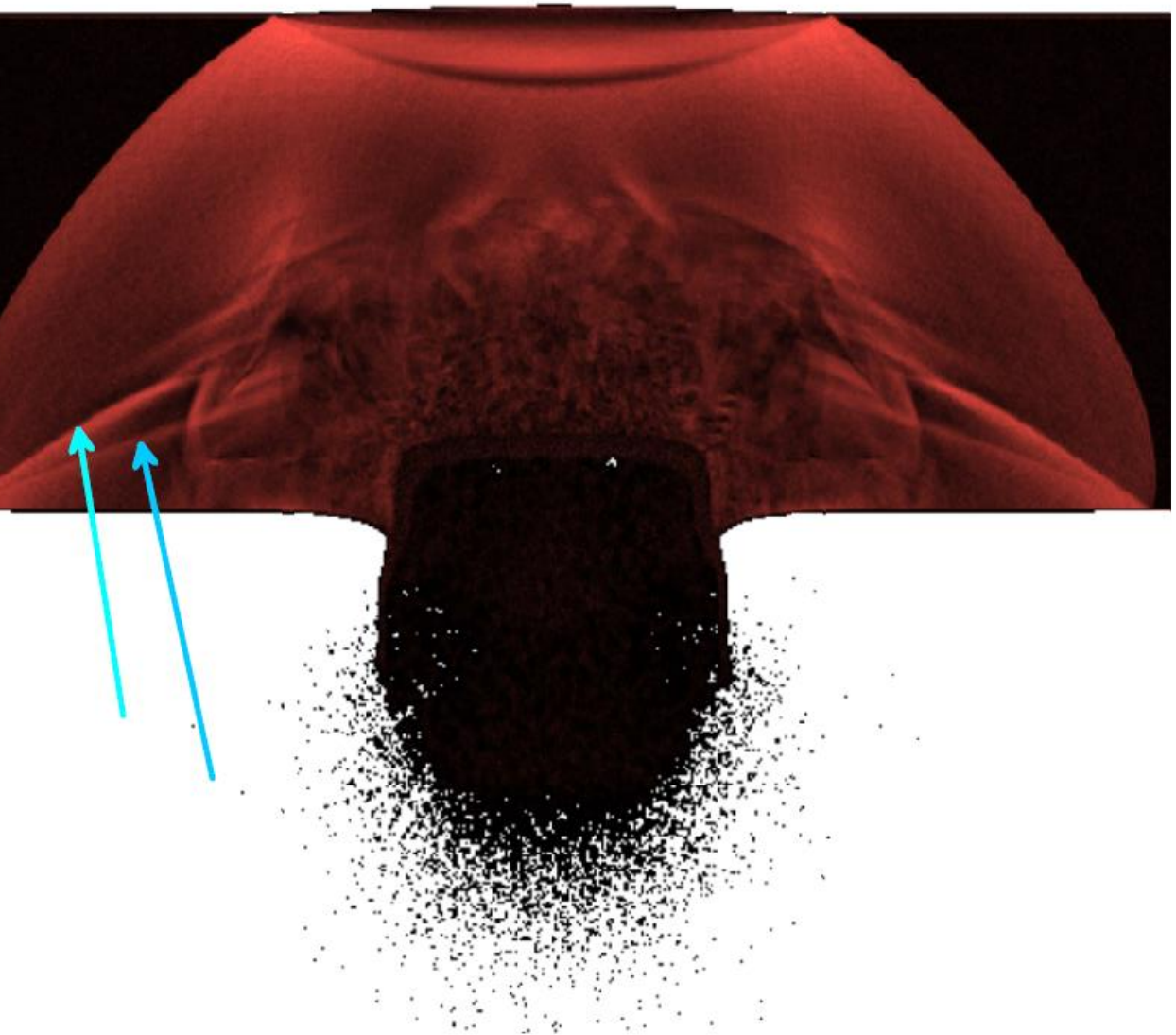
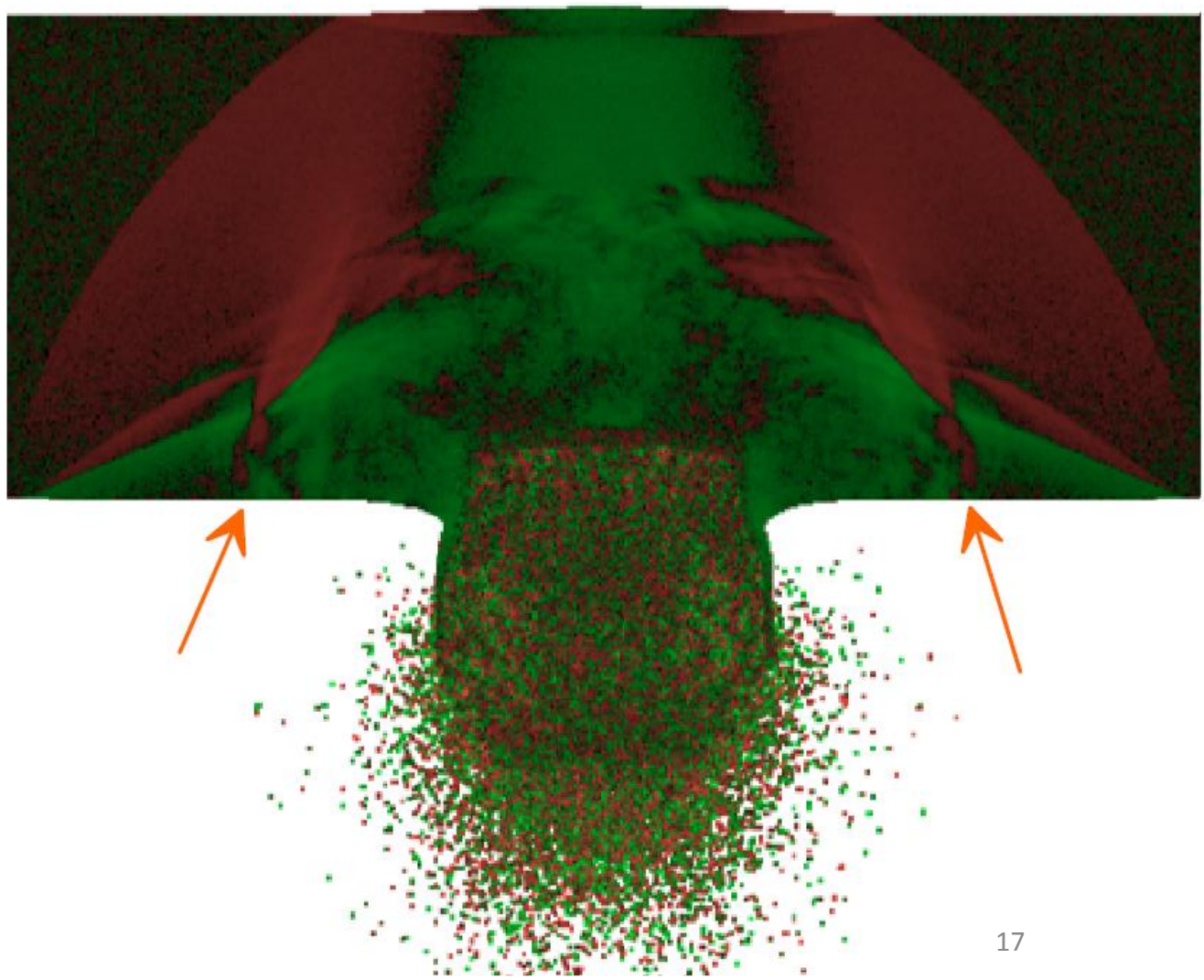


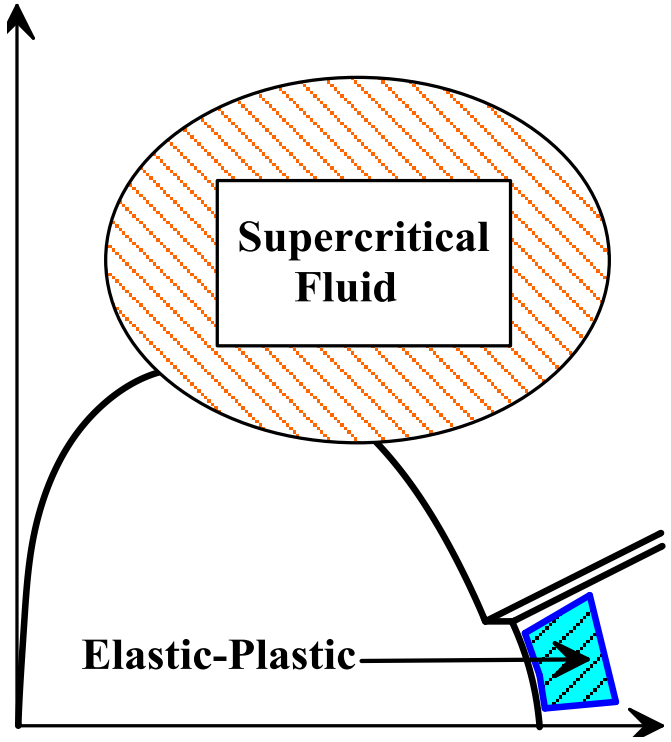
- Elastic-plastic laser shock leaves behind plastically modified matter and transits into pure elastic wave structure.
- The Rayleigh surface wave appears. It is important for laser opto-acoustics applications





CONCLUSION

- It is necessary to improve descriptions in the areas 1 and 2
- Surface tension, contact with water, hydrodynamics of the crossing of the condensation curve
- Combine shockwave melting with elasticity at slightly lower amplitudes



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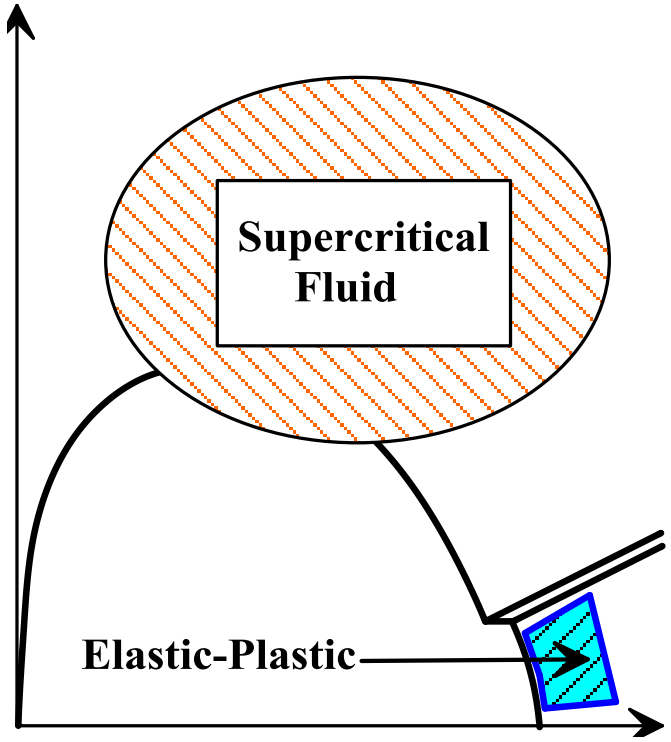
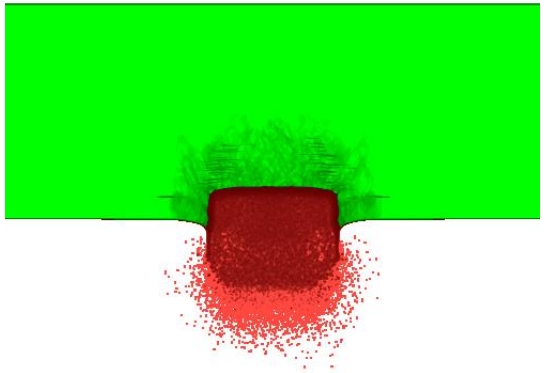


Important works were carried out in JIHT of RAS and Institute of Problems of Chemical Physics of RAS by Kanel, Razorenov, Utkin and their colleagues. These efforts are aimed to do clear the situation in the elastic-plastic area. What we do in our group is devoted to link “SuperCrit” and “Elast-Plast” because both are presented in the same spatial mechanically connected field – this is example where red is hot while green is elastic-plastic region



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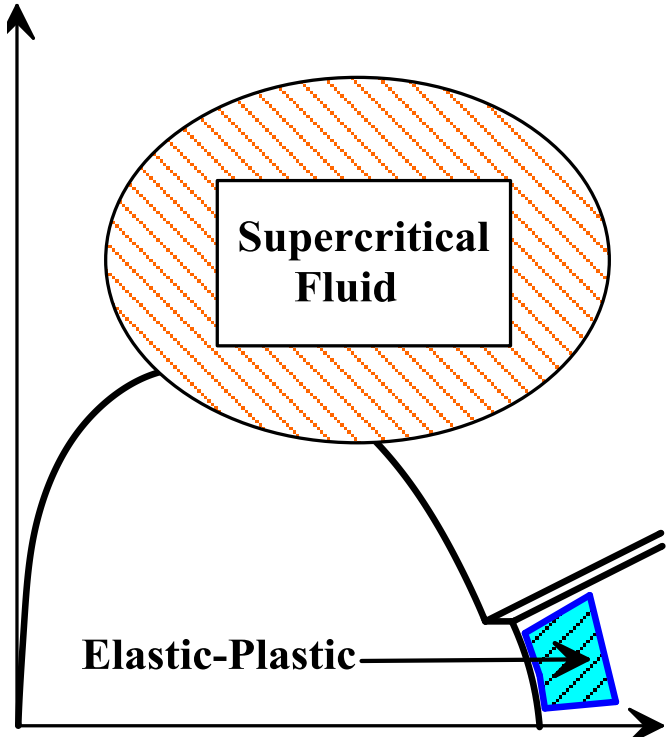

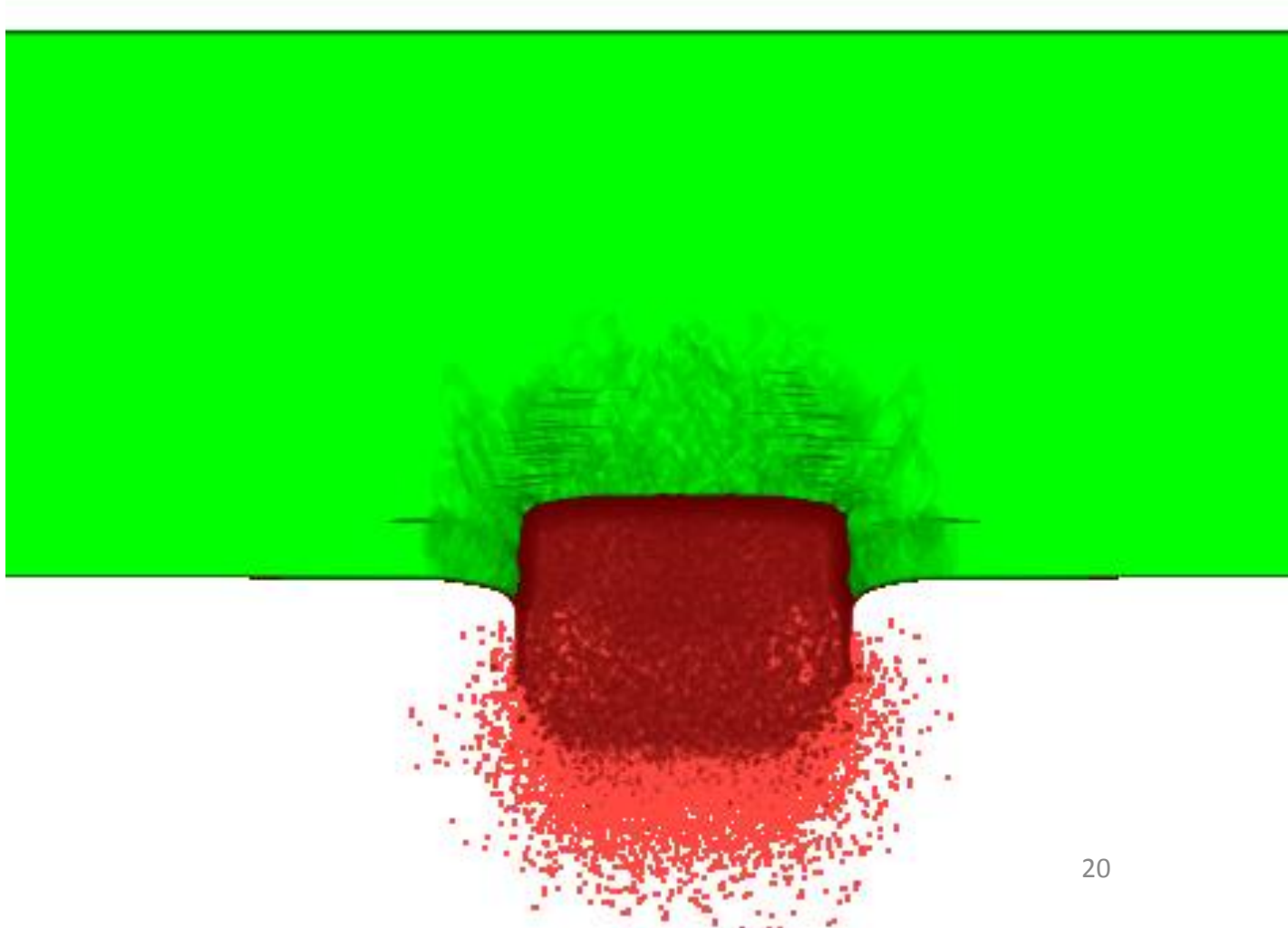

Наша команда

Письма в ЖЭТФ

Физические процессы при лазерной абляции в жидкость

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Письма в ЖЭТФ

Лазерная ударная волна: пластичность, толщина слоя остаточных деформаций и переход из упругопластического в упругий режим распространения

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Many thanks for your kind attention