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Density incrustation at Au-CH interface

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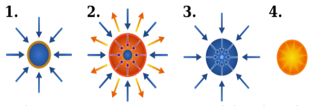
ABSTRACT

- Radiation hydrodynamics (RHD) simulations were performed to study the dynamics at the interface of Au and CH.
- Temperature difference across interface leads to radiation transport & results in formation of a cooling layer (CL).
- Hydrodynamic times scales being much smaller than RT timescale ensure that pressure remains constant in CL leading to DENSITY INCRUSTATION.
- We studied the effect of
  - ➢Temperature of the high Z plasma on the height of incrustation.
  - ➢Density of the low Z arrester material on the height of incrustation .

BACKGROUND

- RHD simulations are essential to the study of high energy density (HED) systems like Inertial Confinement Fusion.



- Coupling of radiation transport and hydrodynamic motion at the interface of high Z and low Z materials leads to a rise in magnitude of density at interface termed density incrustation .
- Density incrustation increases the Atwood number at the interface increasing the growth rate of RT instabilities.
- Phenomena of density incrustation at the interface of low-Z CH plasma and high-Z Au plasma was studied in this work.

(This combination of materials is commonly used in ICF experiments.)

CHALLENGES / METHODS / IMPLEMENTATION

RHD SIMULATIONS USING CODE : RADHYD1 **(developed in ThPS, BARC)**

A. Hydrodynamic equations:

- **LAGRANGIAN SCHEME**
- **STAGGERED MESHES.**

$$\frac{D\rho}{Dt} + \rho\vec{\nabla}.\vec{u} = 0 \qquad (1)$$

$$\rho\frac{D\vec{u}}{Dt} = -\vec{\nabla}(p + q + U/3) \qquad (2)$$

$$\frac{\partial E}{\partial t} + \vec{\nabla}.(E\vec{u}) = -\vec{\nabla}.(P\vec{u}) - \vec{\nabla}.\vec{S} - \vec{\nabla}.\vec{H} + Q_{ext} \qquad (3)$$

$$E = \rho\varepsilon + U + \frac{1}{2}\rho u^2 \qquad (4)$$

$$p = f(\rho, \varepsilon) \qquad (5)$$

B. Radiation transport

- **S-N METHOD FOR ANGLE DISCRETIZATION**
- **GRAY APPROXIMATION FOR FREQUENCY**

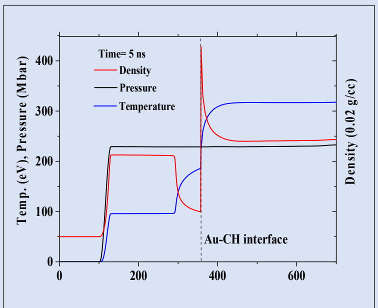
$$\frac{1}{c}\frac{\partial I(x,t,\mu)}{\partial t} + \mu\frac{\partial I(x,t,\mu)}{\partial x} = \rho K_R\left[\frac{ac}{4\pi}T^4 - I(x,t,\mu)\right]$$

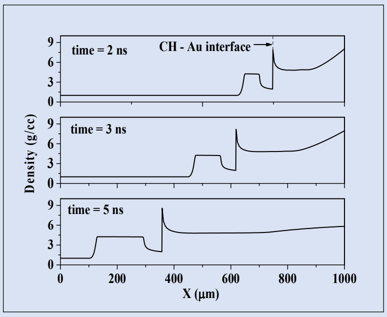
Data Required for RHD simulation

- **Radiative opacity :OPIND code (Based on average atom model)**
- **Equation of state :SBCRIS code (Based on scaled binding energy model)**

At the cooling layer,

- Pressure remains constant over the hydrodynamic time scale.
- Temperature drops due to radiation transport from higher opacity medium to lower opacity medium.
- Peaking in density occurs at the interface.





OUTCOME

EFFECT OF Au TEMPERATURE ON HEIGHT OF DENSITY INCRUSTATION:

(As shown in Fig: 1)

- For same initial density and temperature of CH, the mean free path of radiation inside CH is determined by the temperature of Au plasma.
- Higher the temperature, larger is the penetration of radiation inside CH.
- Temperature drop at the cooling layer is more leading to increasing magnitude of density incrustation.

EFFECT OF CH DENSITY ON HEIGHT OF DENSITY INCRUSTATION:

(As shown in Fig: 2, 3)

- The mean free path of radiation inside the arrester material is determined by initial CH density.
- With increasing density, mean free path decreases and radiation is absorbed more near the cooling layer.
- This decides the drop in temperature across the cooling layer.
- More the drop in temperature, higher is the magnitude of incrustation.

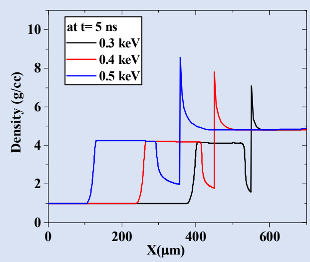


Fig. 1: Magnitude of the incrustation increases with increasing temperature of Au

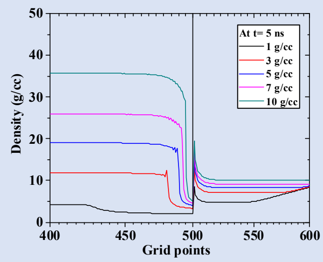


Fig. 2: Magnitude of the incrustation increases with increasing initial density of CH

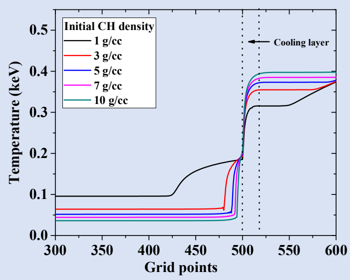


Fig. 3: Temperature drop across cooling layer

CONCLUSION

- ▸Phenomena of density incrustation at the interface of low-Z CH plasma and high-Z Au plasma was studied.
- ▸Density incrustation arises because of the difference in the spatial scales of hydrodynamic motion and radiation transport.
- ▸Its magnitude strongly depends on the temperature of Au plasma as well as the density of the low Z arrester material.
- ▸Density incrustation may increase Atwood number leading to growth of RT instability in the HED systems.
- ▸We have to look for conditions that can possibly reduce the magnitude of the incrustation to as low as possible.

ACKNOWLEDGEMENTS / REFERENCES

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