中国科学院西安光学精密机械研究所
XI'AN INSTITUTE OF OPTICS AND PRECISION MECHANICS OF CAS

光与物质相互作用

李博洋

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阶段目标

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1. 对热传导、相变和相爆炸

2. 库伦爆炸模拟

3. 对库伦爆炸产生的等离子体进行模拟，将模拟给出的辐射光强、等离子体膨胀结果和光谱探测实验数据以及等离子体图像进行对比。

4. 将等离子体密度与光进行耦合，模拟打深孔时效率发生显著下降的情景。

超快激光加工与增材焊接的模拟关注点差别：超快激光加工中90% 以上的材料都是由固态瞬间变为气态完成去除，部分液化材料因气体膨胀飞溅出去。因此对我们对蒸汽的关注度很高。而大部分增材焊接的模拟中未包含对蒸汽的动力学过程。

第一阶段

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Solid & liquid & gas:

Thermo-physics

Liquid & Gas dynamics:

vdW fluid

$$p = \frac{\rho \bar{k}_B T}{1 - \bar{\beta}\rho} - \bar{\alpha}\rho^2$$

10.1103/PhysRevE.92.013021

Surface physics:

Surface tension (already have) +
Wetting (already have)
(+ Marangoni force ?)

Thermo-physics:

Energy equation
diffusion+radiation
Heat source: laser / background

Phase transition:

S — L: Color function
L — G: vdW EOS

10.1016/j.ijheatmasstransfer.2018.10.119

Phase explosion:

vdW: explosive boiling
10.1103/PhysRevE.92.013021

第一步?

起点算例：　test_2d_wetting
参考算例：　test_2d_heat_transfer，将 phi 场相关 code 移植

加入热源：　laser
background

加入固液相变 (与 phi 场耦合?) ：
Color field, latent heat

$$s(T) = \begin{cases} 0 & T < T_m - \dfrac{\delta T}{2} \\ \dfrac{T - (T_m - \delta T/2)}{\delta T} & T_m - \dfrac{\delta T}{2} \leq T \leq T_m + \dfrac{\delta T}{2} \\ 1 & T_m + \dfrac{\delta T}{2} < T \end{cases}$$

$$c_p(T) = \begin{cases} c_p^S & T < T_m - \delta T \\ \dfrac{c_p^S + c_p^L}{2} + \dfrac{\mathscr{L}}{\delta T} & T_m - \dfrac{\delta T}{2} < T < T_m + \dfrac{\delta T}{2} \\ c_p^L & T_m + \delta T < T \end{cases}$$

10.3390/app11072962

第一步?

VdW Fluid： 10.1016/j.ijheatmasstransfer.2018.10.119

Lagrangian, independent from any of the dynamics in the code.

Can be developed based on WC fluid.

$$\frac{d\rho}{dt} = -\rho\nabla \cdot \mathbf{v}$$

$$p = \frac{\rho \bar{k}_b T}{1 - \bar{\beta}\rho} - \bar{\alpha}\rho^2$$

$$\frac{d\mathbf{v}}{dt} = \frac{1}{\rho}\nabla \cdot \mathbf{M} + F_E$$

$$U = \frac{\dim}{2}\bar{k}_b T - \bar{\alpha}\rho$$

$$\frac{dU}{dt} = \frac{1}{\rho}\mathbf{M} : \nabla\mathbf{v} + \frac{\kappa}{\rho}\nabla^2 T + U_E$$

ity, since the attractive term of VDW fluid plays a similar role to surface tension. This method would result in the intrinsic similarity of SPH approximation between attractive force and local curvature. Therefore, new momentum and energy source terms induced by color index formulation have been added into the attractive force interpolation, described as:

$$\frac{dv_{P'}}{dt} = 2\bar{\alpha}\sum_b m_b \varphi_b \nabla W_{ab}^H \tag{16}$$

$$\frac{dU_{P'}}{dt} = \bar{\alpha}\sum_b m_b \varphi_b (\mathbf{v}_b - \mathbf{v}_a) \cdot \nabla W_{ab}^H \tag{17}$$

Bug?


```
//=========================================================================//
Real CompressibleFluid::getPressure(Real rho, Real rho_e)
{
    return rho_e * (gamma_ - 1.0);
}
```

↓

```
Real CompressibleFluid::getPressure(Real rho, Real rho_e)
{
    return rho * rho_e * (gamma_ - 1.0);
}
//=========================================================================//
```