Master thesis

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Contents

1 General equations

1.1 Hydrodynamics

Euler equations, together with closing relation (e.g. ideal gas law).

primitive variables			
mass density	velocity	gas energy density	gas pressure
ρ	v	e	p

1.2 Radiation

Radiative transfer equation: intensity along a ray while interagating with medium. Photons are massless.

$$\left[\frac{1}{c}\partial_t + \vec{n}.\vec{\nabla}\right] I_\nu = \eta_\nu - \chi_\nu I_\nu \tag{1}$$

frequency	intensity	emissivity	total absorbption
u	I_ν	η_ν	χ_ν

These deliver two equations

- the radiative energy equation (diffusion flux $\vec{F}$

$$\frac{\partial E}{\partial t} + \vec{\nabla}.\vec{F} = \iint ...d\nu d\Omega \tag{2}$$

- radiative momentum equation

$$\frac{d\vec{F}}{\partial t} = \iint ...\vec{n}d\nu d\Omega \tag{3}$$

(after **integrating over all frequencies**). Depending on the geometry simplifcations, one can e.g. integrate over all solid angles.

1.3 Radiation-Hydrodynamics

Combination delivers integral-diffusion equation

$$\begin{aligned} \frac{dI}{d\tau} &= S - I \\ &= \int I d\Omega - I \end{aligned} \tag{4}$$

1.4 Challenges

- combination with hydrodynamics
- current analysis: simplified geometries (symmetry). E.g. in 2D, an ADI method is used and now also a multigrid method.
- complex geometry difficult to show in ray-tracing scheme
- steady-state vs. time dependent
- focus on radiation equations

Items that are cited: *The LaTeX Companion* book [GMS93], The Einstein's journal paper [Ein05] and the Dirac's book [Dir81] are physics related items. Next, a citation about *The LaTeX Companion* book [GMS93].

2 Literature study

General guidelines for good practices in scientific computing are found in [Wil+14].

Items about general astrophysics are

I went to the 2019 Petnica Summer school in Petnica, Serbia.

References

[Dir81] Paul Adrien Maurice Dirac. *The Principles of Quantum Mechanics*. International series of monographs on physics. Clarendon Press, 1981. ISBN: 9780198520115.

[Ein05] Albert Einstein. "Zur Elektrodynamik bewegter Körper. (German) [On the electrodynamics of moving bodies]". In: *Annalen der Physik* 322.10 (1905), pp. 891–921. DOI: http://dx.doi.org/10.1002/andp.19053221004.

[GMS93] Michel Goossens, Frank Mittelbach, and Alexander Samarin. *The LaTeX Companion*. Reading, Massachusetts: Addison-Wesley, 1993.

[Wil+14] Greg Wilson et al. "Best Practices for Scientific Computing". In: *PLoS Biology* 12.1 (2014), pp. 1–18. ISSN: 15449173. DOI: 10.1371/journal.pbio.1001745. arXiv: arXiv:1210.0530v4.