GEAR-RT - Radiative Transfer with SWIFT

Radiation Hydrodynamics with Meshless Methods, the M1 Closure, Interdependent Tasking, and Sub-Cycling with Individual Timestepping

Mladen Ivkovic

12. August 2022

LASTRO
École Polytechnique Fédérale de Lausanne

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testing notes

Equations of Radiative Transfer

Can we assume $\frac{\partial I_\nu}{\partial t} \approx 0$?

Yes, if we are primarily focussing on the **fluid flow** as opposed to the **radiation flow**.

- Optically thin regime:
  $t_{fluid} \sim l/v$
  $t_{rad} \sim l/c$
  $\Rightarrow t_{rad}/t_{fluid} = \mathcal{O}(v/c), t_{rad} \ll t_{fluid}$

So the radiation field has ample time to adjust itself to the changes induced by the fluid.

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Optical Depth

A few more words on τ_ν:

If x and x' are two points in the medium separated by $l = |\mathrm{x}' - \mathrm{x}|$, the optical depth **between them** is

$$\tau_\nu(\mathbf{x}, \mathbf{x}') = \int_0^l \alpha_\nu(\mathbf{x} + \mathbf{n}s; \mathbf{n}, \nu) \mathrm{d}s$$

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Monte Carlo Radiative Transfer Method

We have a nice equation for Radiative Transfer along the ray - so let’s use it!

Each radiation source emits photon packets with

- some direction θ, ϕ
- some energy / photon number
- some frequency

Follow the packets, and solve the RT equation along the path of the ray.

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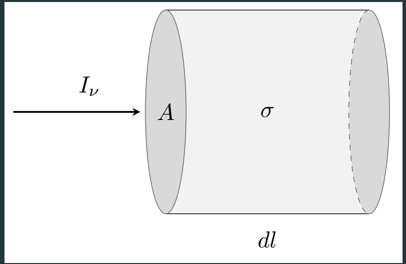
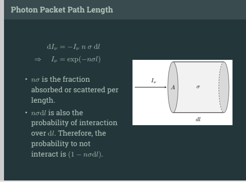
Photon Packet Path Length

$$
\begin{aligned}
\mathrm{d}I_\nu &= -I_\nu \, n \, \sigma \, \mathrm{d}l \\
\Rightarrow \quad I_\nu &= \exp(-n\sigma l)
\end{aligned}
$$

- $n\sigma$ is the fraction absorbed or scattered per length.
- $n\sigma\mathrm{d}l$ is also the probability of interaction over $\mathrm{d}l$. Therefore, the probability to not interact is $(1 - n\sigma\mathrm{d}l)$.





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$\Rightarrow \quad I_\nu = \exp(-n\sigma l)$
$n\sigma$ is the fraction absorbed or scattered per length.
$n\sigma dl$ is also the probability of interaction over dl. Therefore, the probability to not interact is $(1 - n\sigma dl)$.