

Resolución de la ecuación de transporte mediante el método de las características en el código neutrónico milonga

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XLIII Reunión Anual de la Asociación Argentina de Tecnología Nuclear

Wasora

- ▶ Free software, both as in free speech and as in free beer;
- ▶ Wasora should be seen as a syntactically-sweetened way to ask a computer to perform a certain mathematical calculation:

$$\begin{aligned}\dot{x} &= \sigma (y - x) \\ \dot{y} &= x (r - z) - y \\ \dot{z} &= xy - bz\end{aligned}$$

```
# lorenz ' seminal dynamical system solved with wasora
PHASE_SPACE x y z
end_time = 40

# parameters that lead to chaos
sigma = 10
r = 28
b = 8/3

# initial conditions
x_0 = -11
y_0 = -16
z_0 = 22.5

# the dynamical system (note the dots before the '=' sign)
x_dot := sigma*(y - x)
y_dot := x*(r - z) - y
z_dot := x*y - b*z

# write the solution to the standard output
PRINT t x y z
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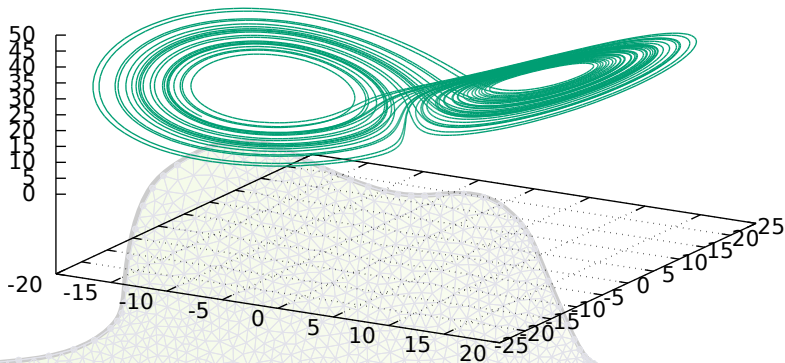
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Wasora suite

The set of codes that comprise the wasora code plus its plugin is also known as *wasora suite*:

- ▶ **wasora**: the main code that solves general mathematical problems and loads one or more plugins
- ▶ **skel**: template to write a wasora plugin from scratch
- ▶ **bessugo**: a graphical visualization plugin for wasora
- ▶ **milonga**: core-level neutronic code that solves neutron diffusion or transport on unstructured grids
- ▶ **fino**: plugin to solve general partial differential equations using the finite element method
- ▶ **xdfrpf**: plugin to extract Data From Relap Restart-Plot Files and use it as wasora input
- ▶ **waspy**: plugin to solve problems using wasora
- ▶ **qdp**: a shell to interact with wasora from the commandline
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- ▶ **waspy**: plugin to plot the results of a wasora simulation
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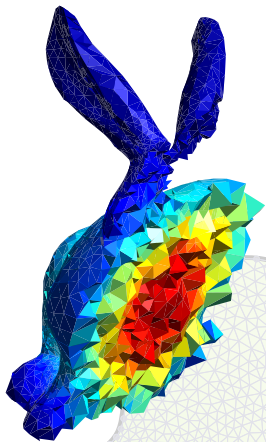
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Milonga

Milonga is a free core-level neutronic code that solves the steady-state multigroup neutron transport equation.



Formulations:

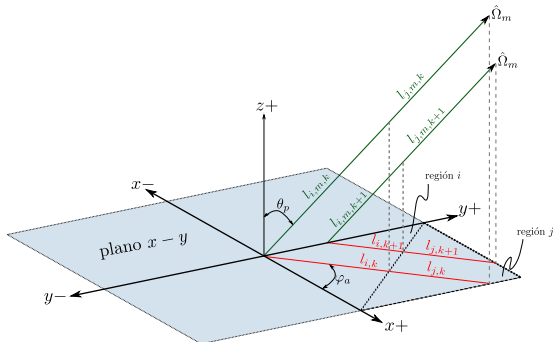
- ▶ Diffusion.
- ▶ Discrete ordinates (S_N).
- ▶ Lattice(?):

We choose the Method of Characteristics.

Method of Characteristics

Basics

Solves the characteristic form of the transport equation by following straight neutron paths.



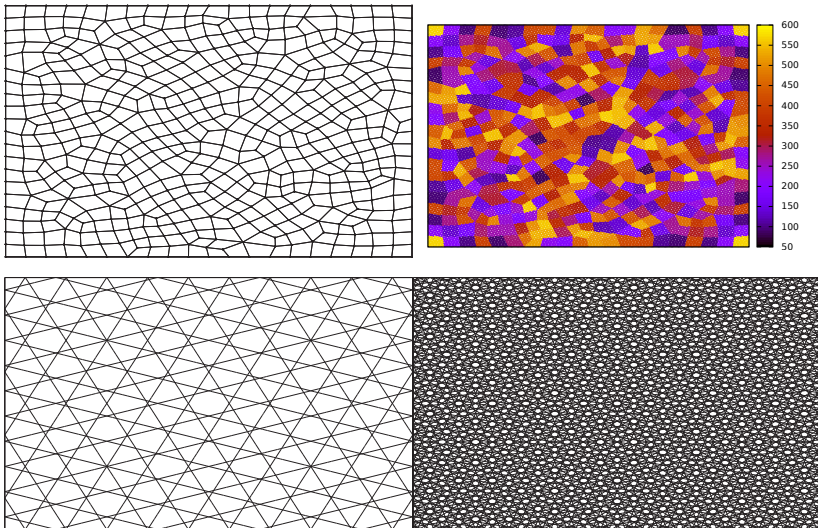
$$\hat{\Omega} \cdot \text{grad} [\psi_g(\mathbf{x}, \hat{\Omega})] + \Sigma_g^t(\mathbf{x}) \cdot \psi_g(\mathbf{x}, \hat{\Omega}) = q_g(\mathbf{x}, \hat{\Omega})$$

$$\frac{d}{ds} \psi_{i,g,m,k}(s) + \Sigma_{i,g}^t \cdot \psi_{i,g,m,k}(s) = q_{i,g,m}$$

Method of Characteristics

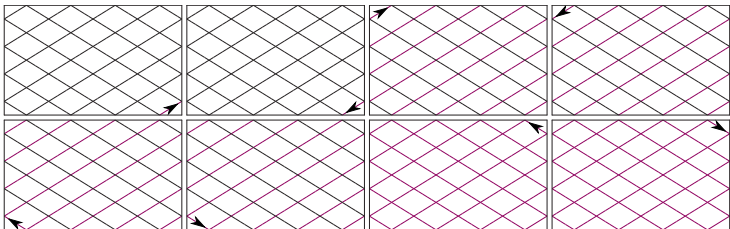
Ray tracing

Milonga handles both structured and unstructured meshes.



Method of Characteristics

Solver



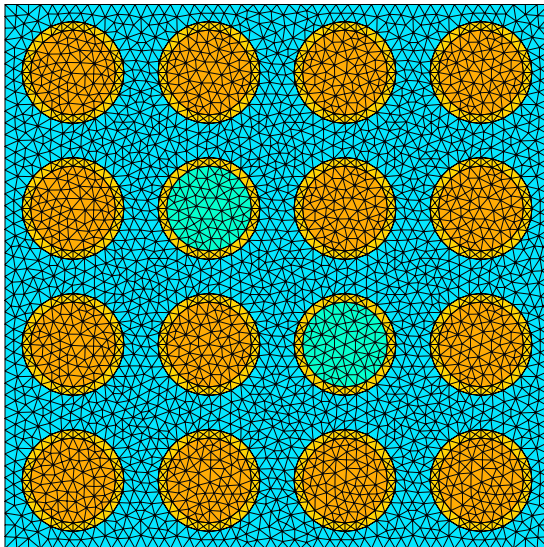
$$q_{i,g,m} = q_{i,g} = \frac{1}{4\pi} \left(\sum_{g'=1}^G \Sigma_{i,g' \rightarrow g}^s \cdot \phi_{i,g'} + \frac{\chi_g}{k_{\text{eff}}} \sum_{g'=1}^G \nu \Sigma_{i,g'}^f \cdot \phi_{i,g'} \right)$$

$$\Delta\psi_{i,g,m,k} = \psi_{i,g,m,k}^{\text{in}} - \psi_{i,g,m,k}^{\text{out}} = \left(\psi_{i,g,m,k}^{\text{in}} - \frac{q_{i,g}}{\Sigma_{i,g}^t} \right) (1 - e^{-\tau_{i,g,m,k}}).$$

$$\phi_{i,g} = \frac{4\pi}{\Sigma_{i,g}^t} \left[q_{i,g} + \frac{1}{A_i} \sum_m \left(w_m \delta_m \sin \theta_p \sum_{k \in K(i,m)} \Delta\psi_{i,g,m,k} \right) \right]$$

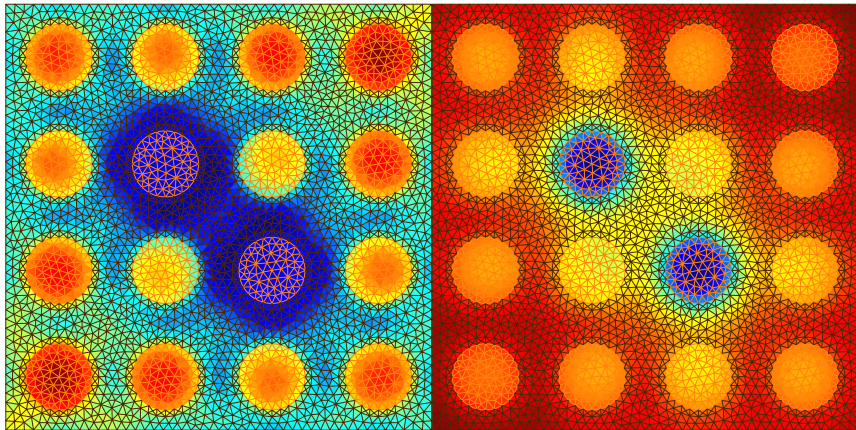
Milonga

Benchmarking



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The end

Thank you!