IDSimple

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Abstract

Sets up simple initial data sets for the 3-metric, extrinsic curvature and lapse

1 Purpose

This thorn provides simple initial data sets for the 3-metric, extrinsic curvature and lapse.

2 Initial Data for 3-metric and Extrinsic Curvature

2.1 Minkowski Initial

Currently only Cartesian coordinates are supported, and the metric and extrinsic curvature are set as:

$$
\begin{aligned}
g_{xx} = g_{yy} = g_{zz} &= 1 \\
g_{xy} = g_{xz} = g_{yz} &= 0 \\
K_{ij} &= 0
\end{aligned}
$$

Depending on the `metric_type` and `conformal_storage` the conformal factor is set to

$$
\begin{aligned}
\psi &= 1 \\
\psi_{,i} &= 0 \\
\psi_{,ij} &= 0
\end{aligned}
$$

3 Initial Data for Lapse Function

3.1 Gaussian

Choosing `initial_lapse = "gaussian"` provides a gaussian bump in the initial lapse grid function `alp`. This is mainly useful for testing purposes.

$$
\alpha = 1 + A \exp(-r^2/\sigma^2)
$$

where the amplitude A and square of the width σ^2 of the bump are set using the parameters `gaussian_amplitude` and `gaussian_sigma2`. This choice of lapse is commonly termed `flatty`.

3.2 Psi Minus Two

The `psiminustwo` choice of initial lapse sets

$$
\alpha = \left(\frac{1 - 2s + s\psi}{\psi - s} \right)^2
$$

The cut off value s (parameter `psiminustwo_cut` must lie between zero and one. If $s = 0$ then $\alpha = 1/\psi^2$, while if $s = 1$ then $\alpha = 1$. This gauge choice can only be used with `metric_type = "static conformal"`.

This choice of lapse was originally implemented as an experiment to improve the initial profile of the lapse for $1 + \log$ slicing (see the documentation for the ADM or BSSN thorns). This condition is not elliptic, and the effect of the collapse of the lapse around the singularities propagates outward with a finite gauge speed, resulting in a visible "kink" in the lapse function. For data such as the Brandt-Brügmann puncture data, the `psiminustwo` lapse falls off asymptotically in the same way as maximal slicing, and already posesses the collapse feature at the puncture, and thus is a potentially useful initial profile for puncture-type evolutions.

3.3 Isotropic

The isotropic choice sets the lapse to

$$\alpha = \frac{2}{\psi} - 1$$

which provides the exact isotropic lapse for a single black hole in isotropic coordinates. This gauge choice can only be used with `metric_type = "static conformal"`.