

Figures of Lecture 1: Null hypersurfaces and event horizons

Éric Gourgoulhon

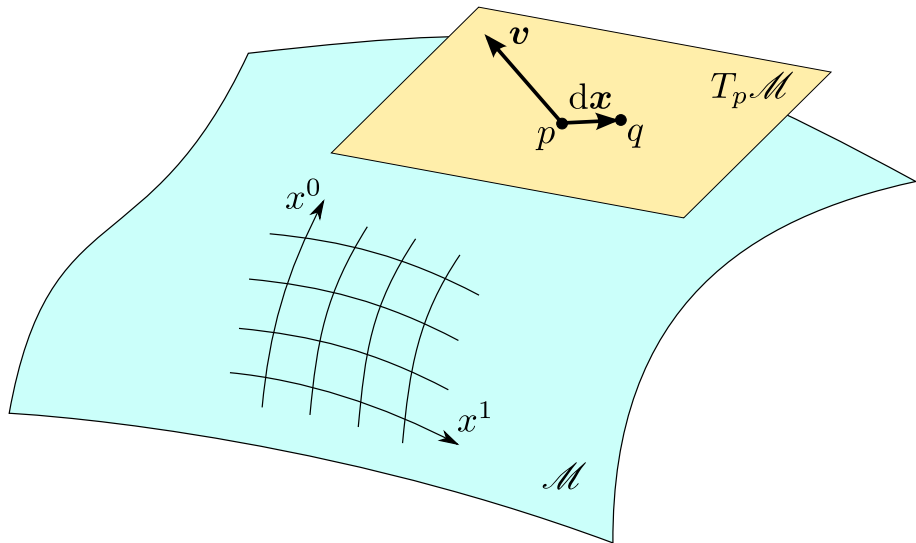
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CNRS / Observatoire de Paris / Université Paris Diderot
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<http://luth.obspm.fr/~luthier/gourgoulhon/>

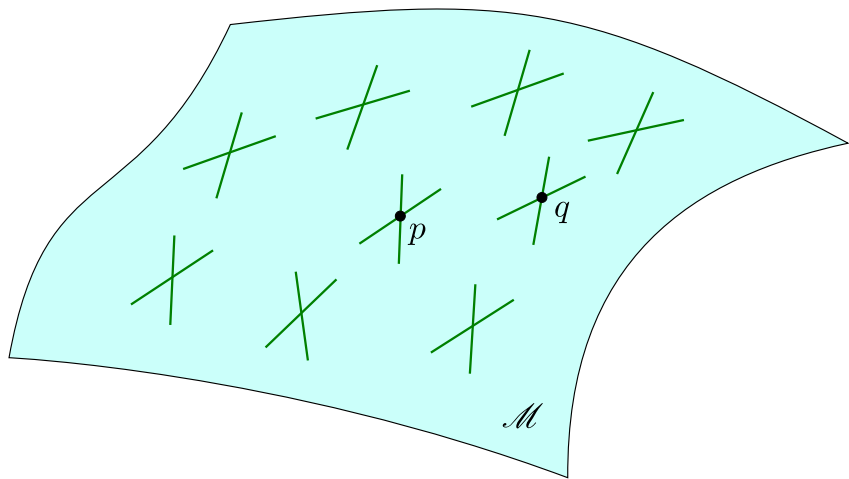
CP3, UCL, Louvain-la-Neuve
28 November 2016

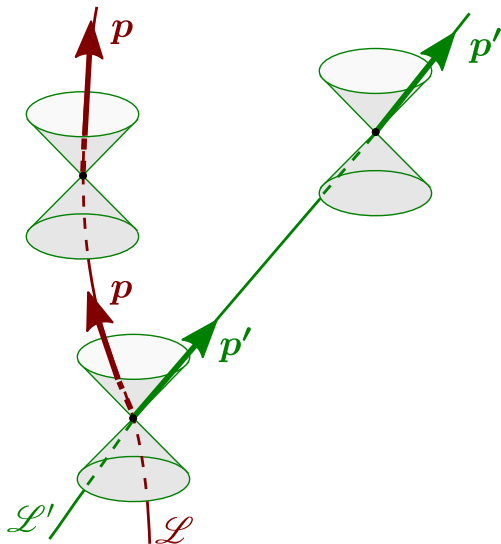
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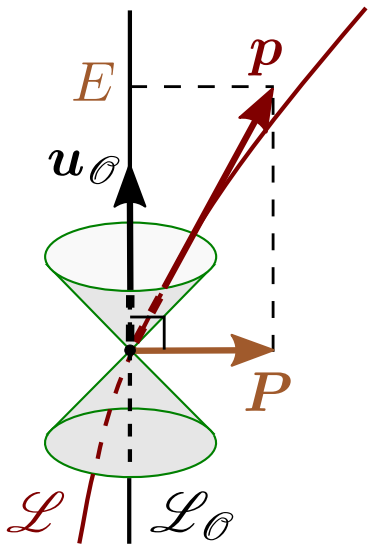
Smooth manifold

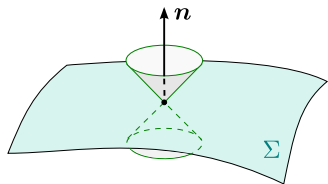


Lorentzian manifold

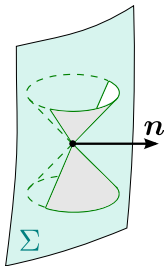




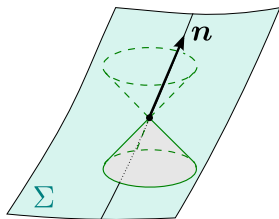




spacelike

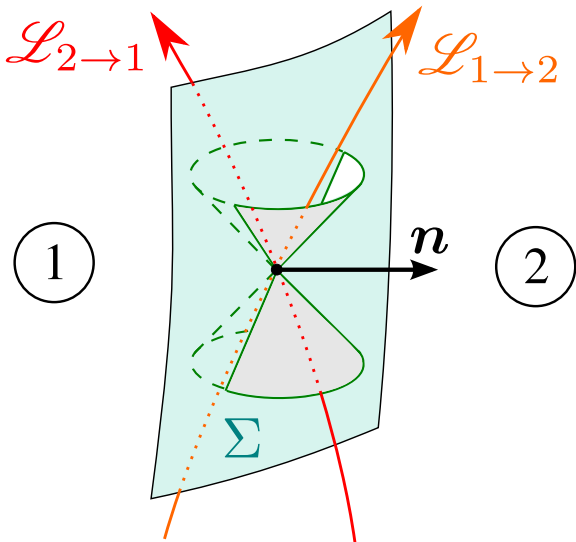


timelike

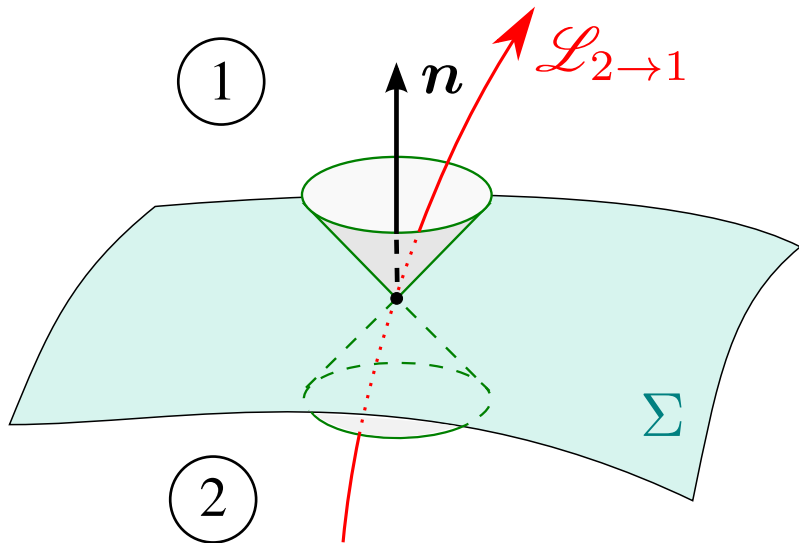


null

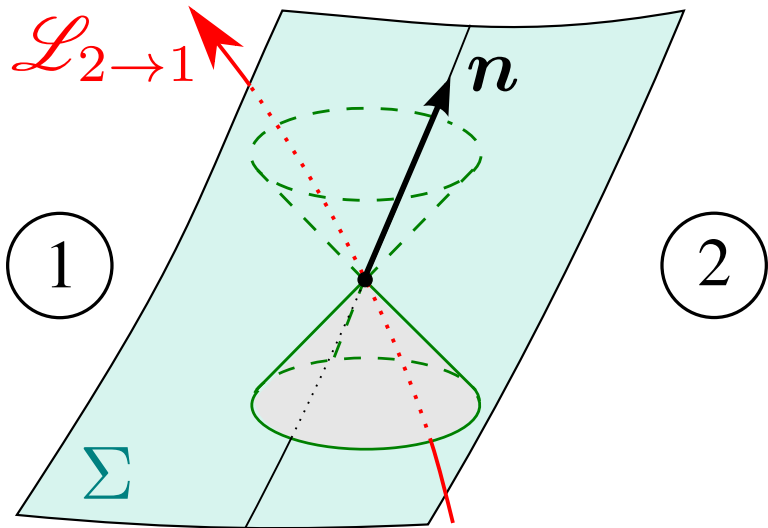
Timelike hypersurface : 2-way membrane



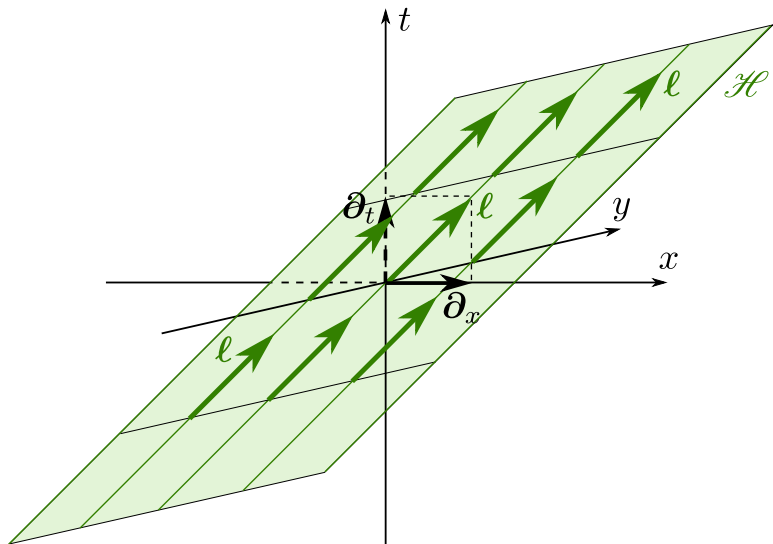
Spacelike hypersurface : 1-way membrane



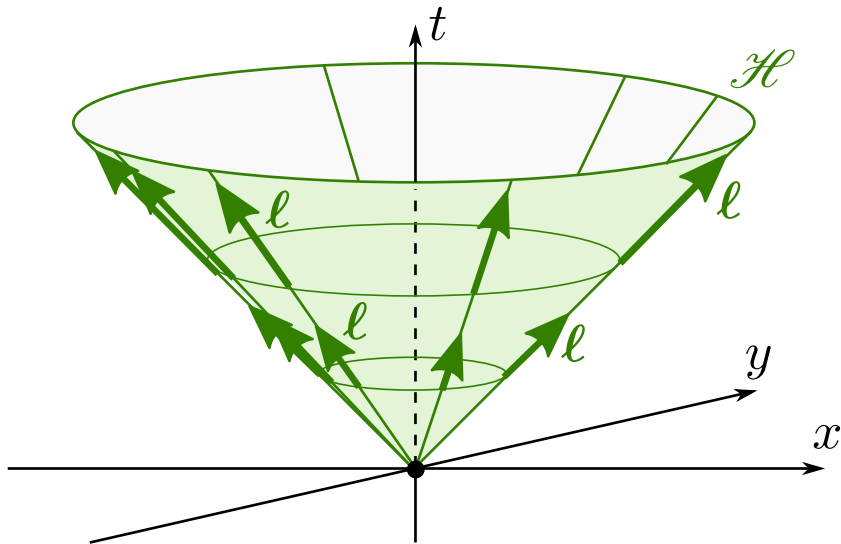
Null hypersurface : 1-way membrane



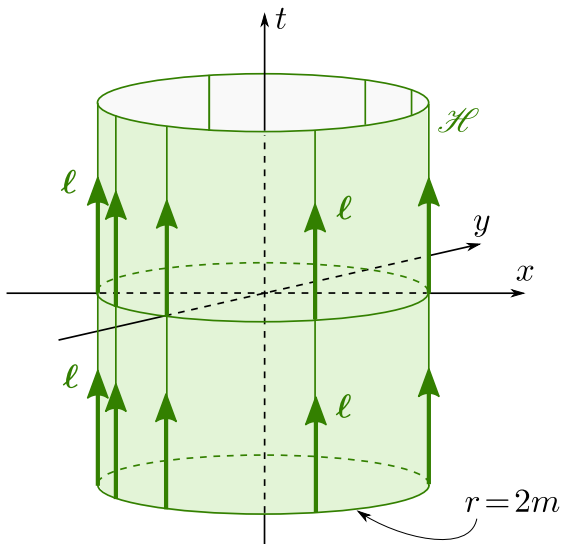
Null hyperplane in Minkowski spacetime



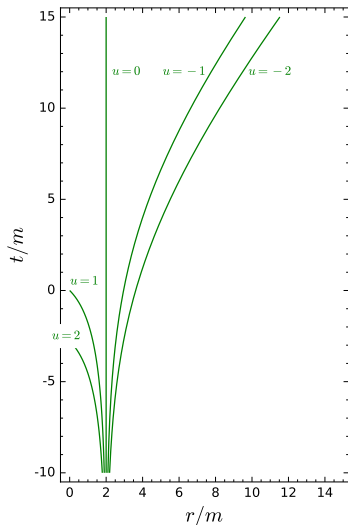
Future null cone in Minkowski spacetime



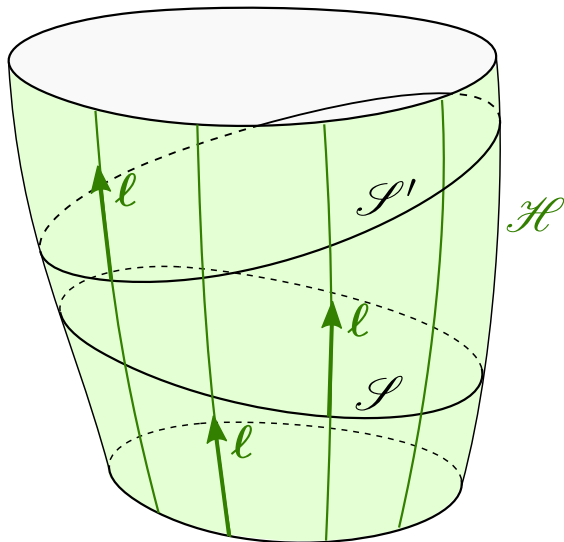
Schwarzschild horizon (in Eddington-Finkelstein coordinates)



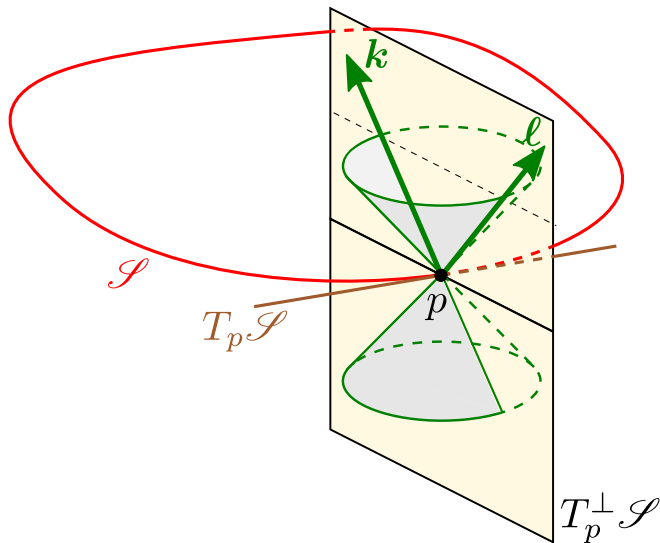
Constant u hypersurfaces around the Schwarzschild horizon



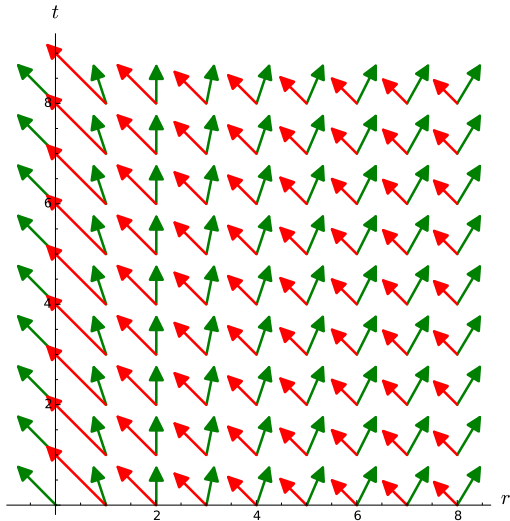
Cross-sections of a null hypersurface



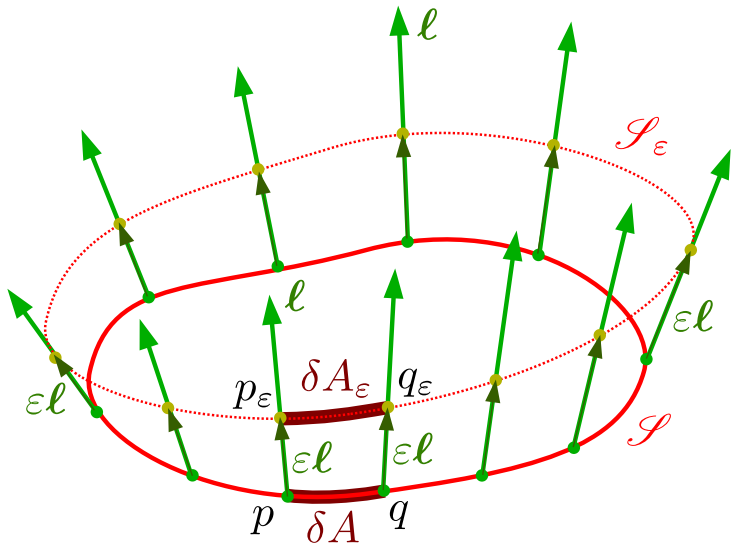
Null normals to a spacelike surface



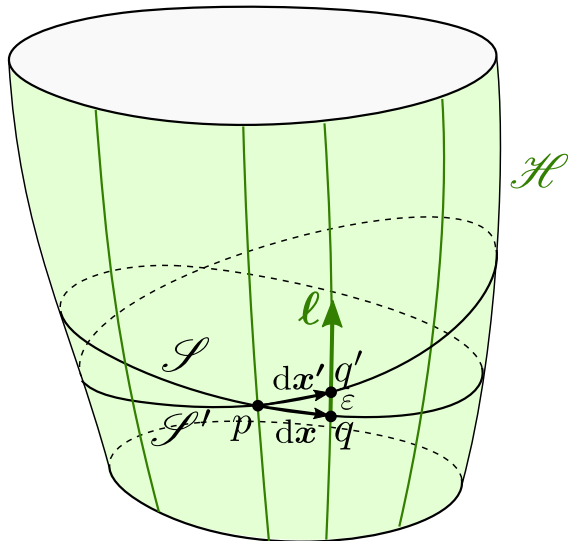
Null normals around the Schwarzschild horizon



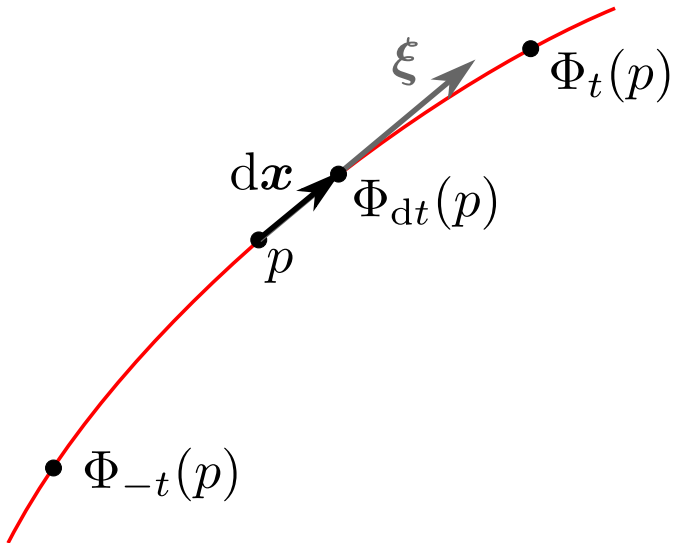
Lie dragging along a null normal



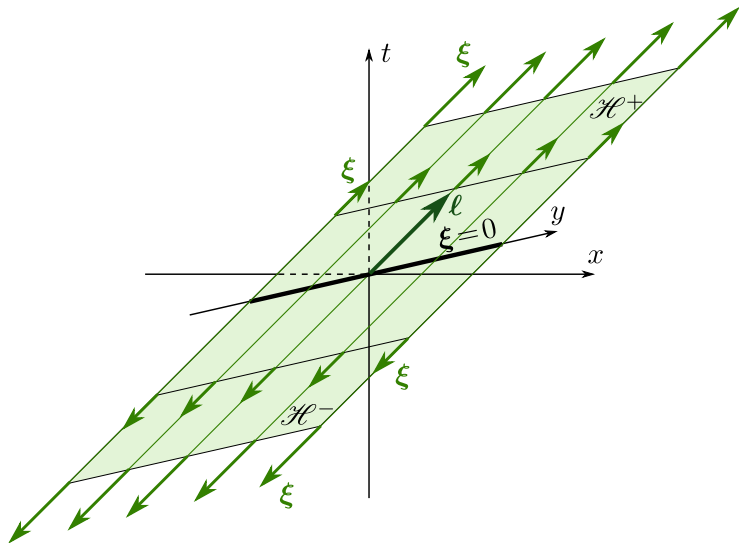
Independence of the expansion from the cross-section



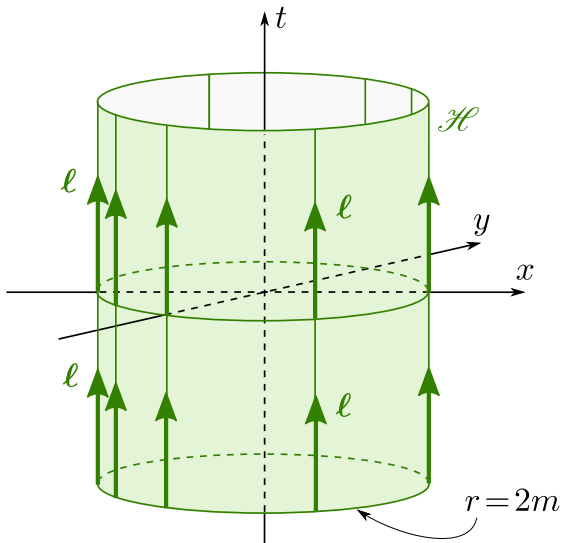
Generator of a 1-dimensional group action



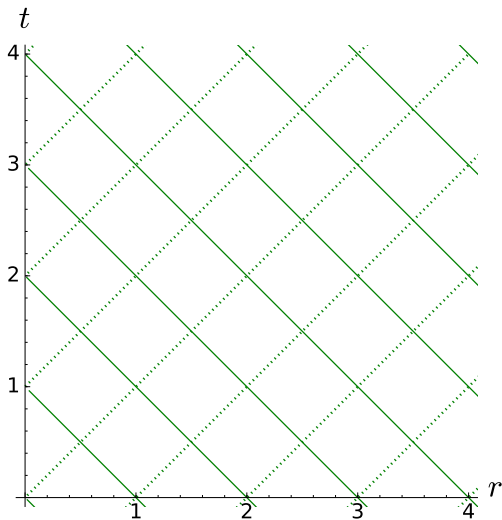
Null half-hyperplanes as Killing horizons



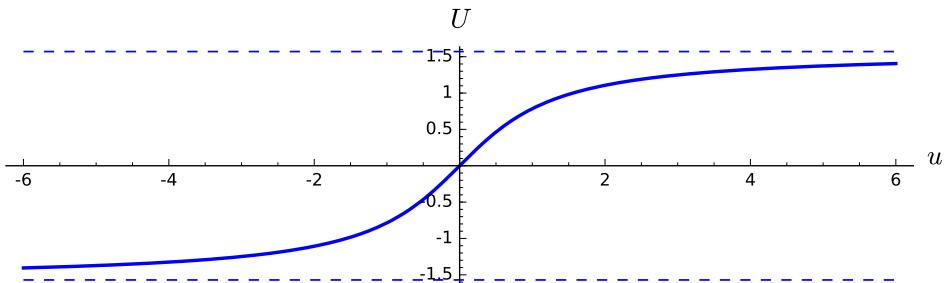
Schwarzschild horizon as a Killing horizon



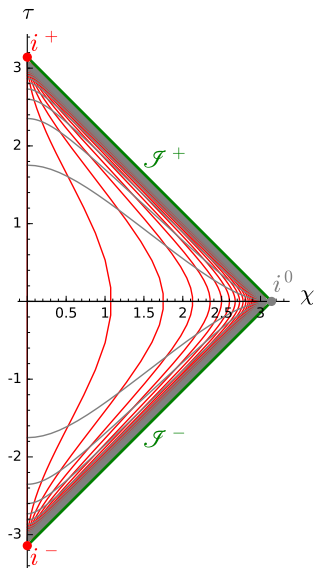
Radial null coordinates in Minkowski spacetime



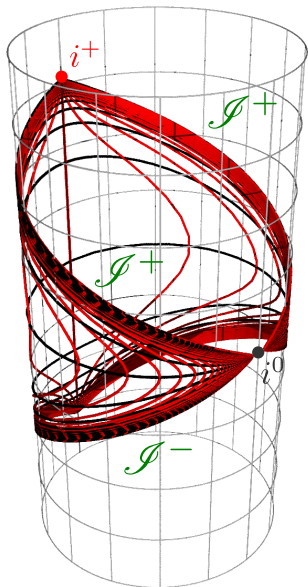
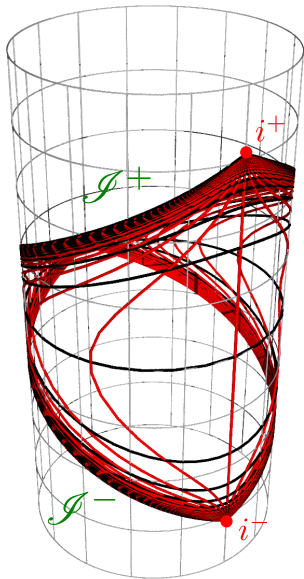
The arctangent function, mapping \mathbb{R} to $(-\pi/2, \pi/2)$



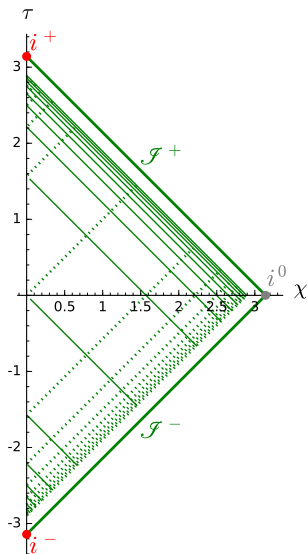
Conformal diagram of Minkowski spacetime



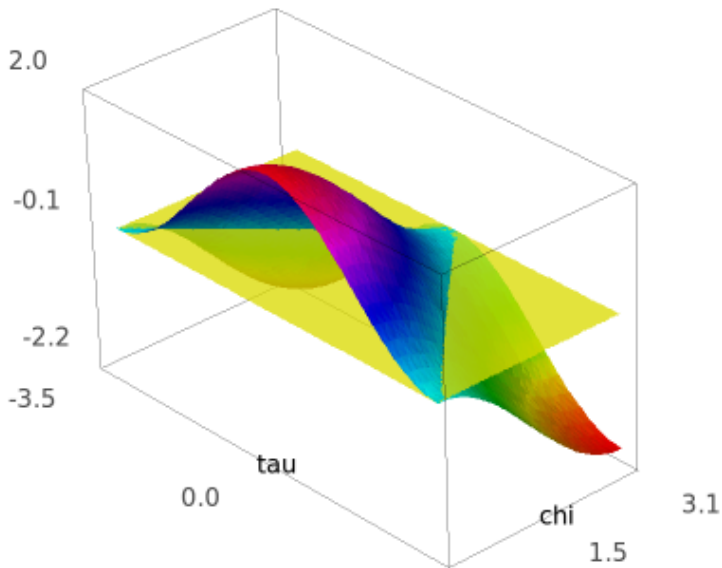
Minkowski spacetime in the Einstein cylinder



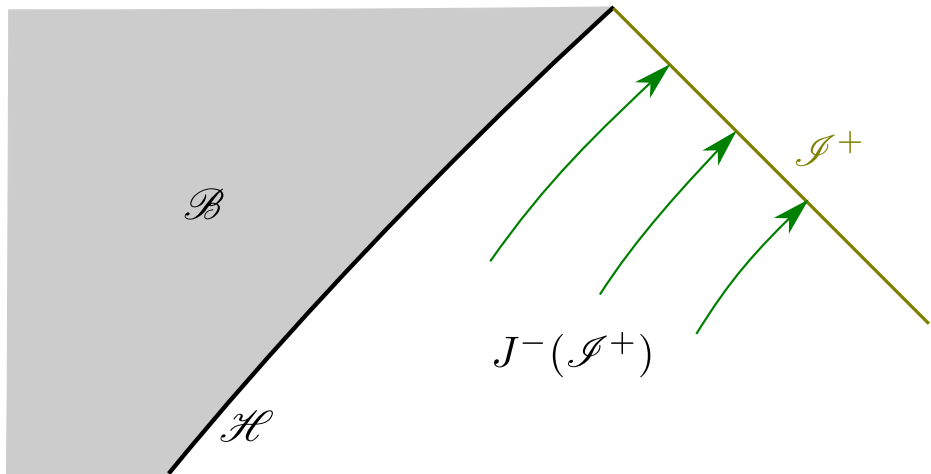
Radial null geodesics in Minkowski spacetime



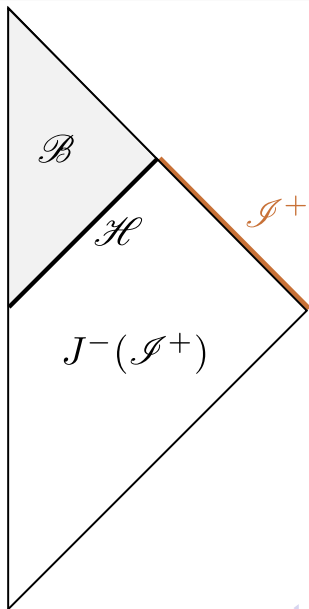
Conformal factor (Minkowski spacetime)



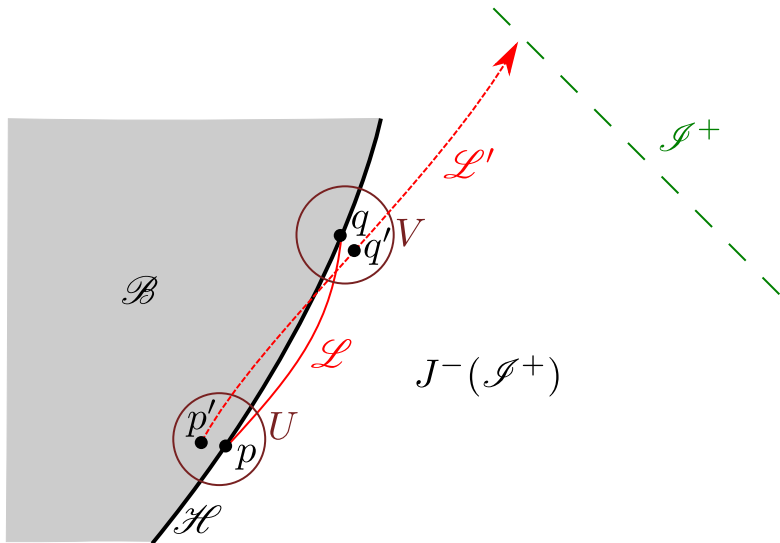
Definition of a black hole



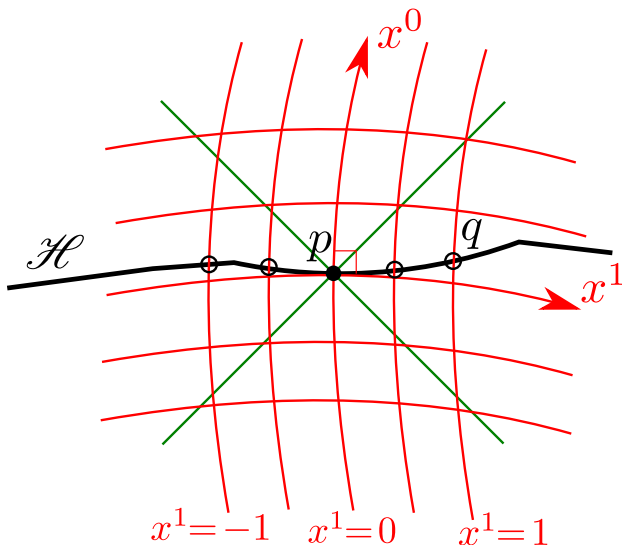
“Spurious” black hole with incomplete \mathcal{I}^+



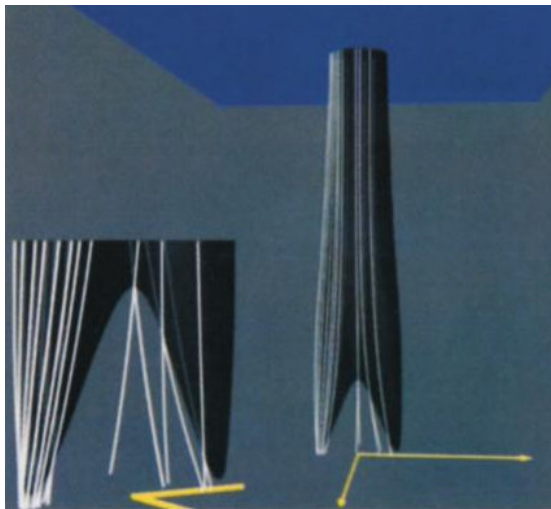
Proving that \mathcal{H} is achronal



Proving that \mathcal{H} is a topological manifold of dimension $n - 1$

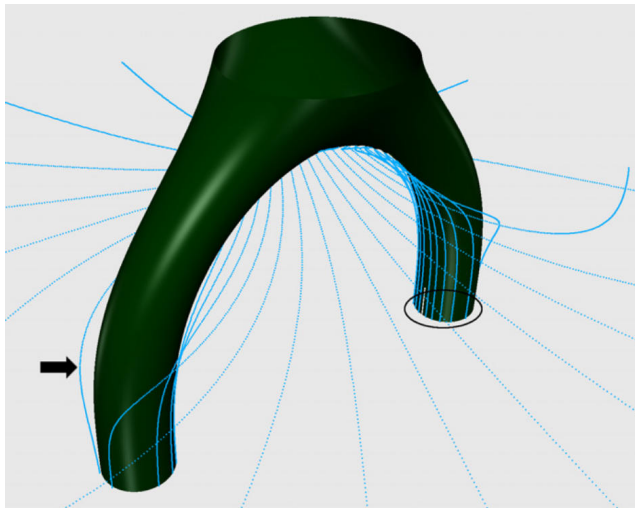


Event horizon of a black hole head-on merger



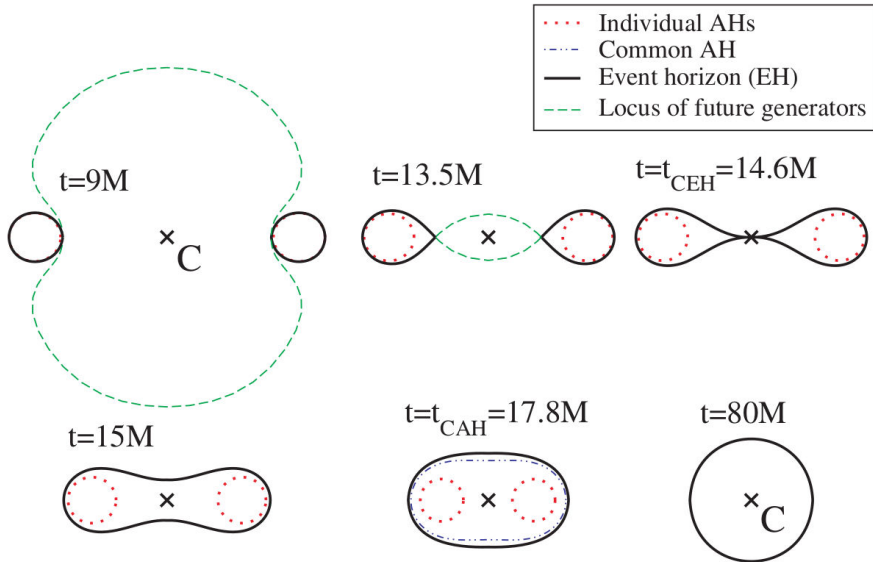
Source : Matzner et al. (1995)

Event horizon of a black hole head-on merger



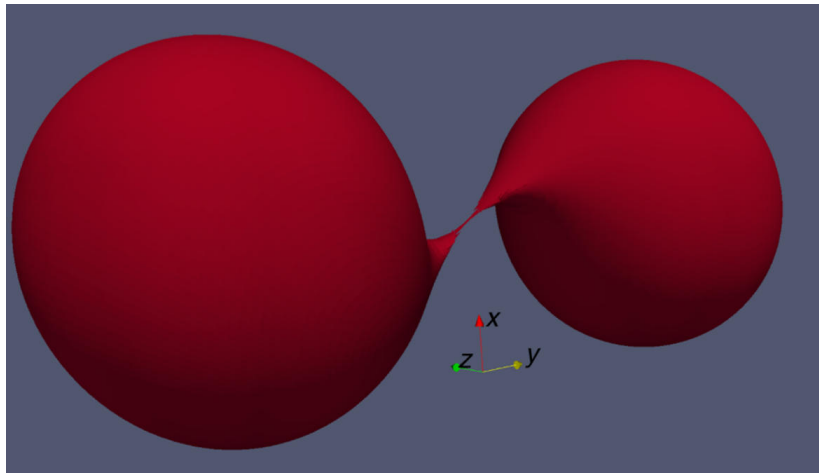
Source : Cohen et al. (2009)

Cross-sections of the event horizon of a head-on merger



Source : Cohen et al. (2009)

Cross-section of the event horizon in an inspiralling merger



Source : Cohen et al. (2012)