KRUSKAL-SZEKERES DIAGRAMS: ANOTHER SPACE SHIP DISASTER

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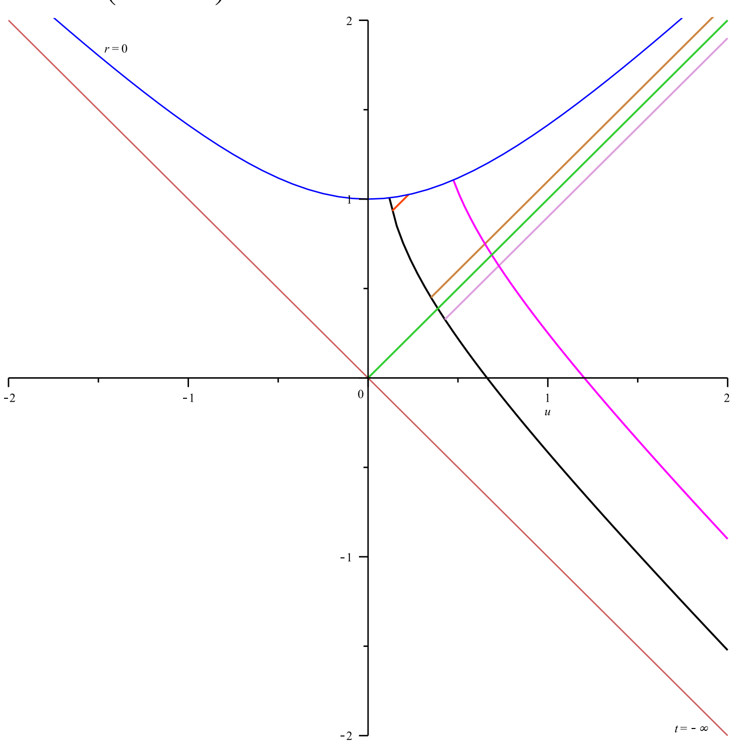
Reference: Moore, Thomas A., *A General Relativity Workbook*, University Science Books (2013) - Chapter 15; Problem 15.8.

In this example, we have a spaceship originally at some fixed distance from a black hole, but the engines fail and the ship starts to fall vertically downward (tail first) towards the black hole.



In the KS diagram, the tail of the ship follows the black world line and the front of the ship follows the parallel magenta world line. The diagonal lines with slope $+1$ indicate photons emitted by the tail end (with the green line being also the event horizon). The violet photon is emitted before the tail crosses the horizon and is received by the front before it crosses the horizon. A photon emitted just as the tail crosses the horizon follows the green world line, and since this line also corresponds to a constant $r = 2GM$, the photon remains at the event horizon and is received by the front when the front crosses the horizon. The brown photon leaves the tail after it crosses the horizon and is received by the front after *it* too crosses the horizon. Thus there isn't any time during the period where the ship is crossing the horizon that the front receives no photons from the tail, but any photons received by the front are emitted by the tail when both the front and the tail are on the same side of the horizon. When the front is outside the horizon and the tail is inside, the front still sees the tail, but it is seeing the tail as it was before it crossed the horizon.

Closer to the singularity at $r = 0$, however, there is a cutoff point beyond which any photons (such as the short red line) emitted by the tail are absorbed at $r = 0$ before reaching the front, so the front end will not be able to see the tail hit $r = 0$.