KRUSKAL-SZEKERES METRIC: MORE FUN WITH PHOTONS

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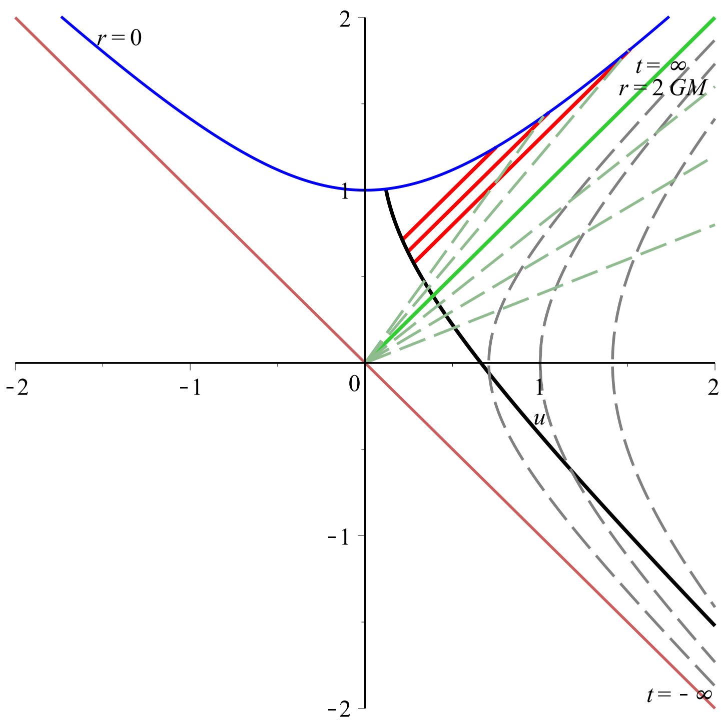
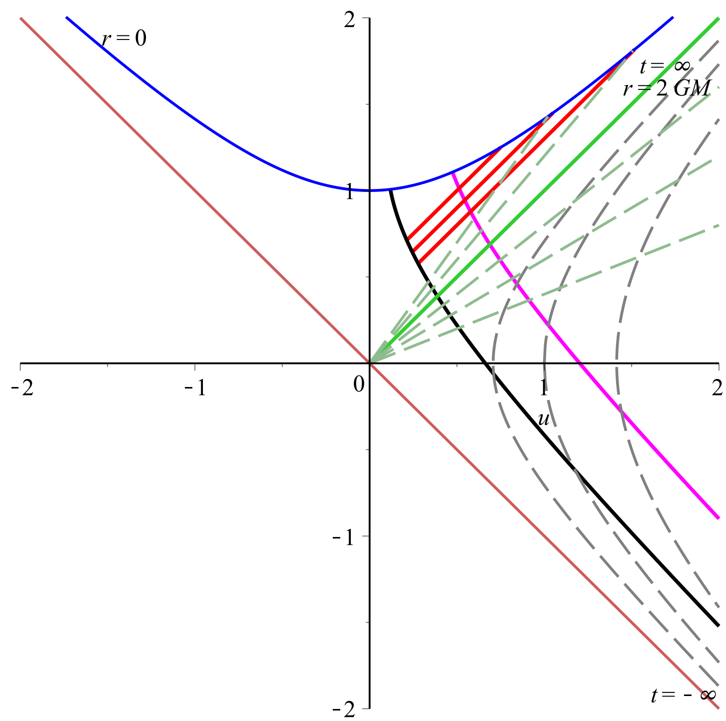
Reference: Moore, Thomas A., *A General Relativity Workbook*, University Science Books (2013) - Chapter 15; Problems 15.5, 15.6.

Here's another example of using a Kruskal-Szekeres (KS) diagram. We have the same observer in a space ship falling into a black hole as before, but this time he is firing photon torpedoes radially outward. If these torpedoes follow photon world lines is there any danger that they will hit the ship before it reaches $r = 0$? It might seem this is possible, since everything (even light) moves inwards inside the event horizon, so both the torpedoes and the ship are heading for $r = 0$. However, looking at the KS diagram, we see this won't happen:



The ship is the heavy black curve. Photons fired radially outwards will have world lines with slope +1, so the three heavy red lines represent three torpedoes fired from the ship after it enters the event horizon. We can see that these torpedoes won't hit the ship, although they will get absorbed by the singularity at $r = 0$.

As a variant on this problem, suppose that the black curve represents the surface of a collapsing star instead of a falling space ship. After the star collapses through its event horizon, it can still emit photons radially outwards. If another ship fell into the event horizon as the star is collapsing, it might follow the thick purple world line.



Since the ship's world line intersects the lines of the emitted photons, this observer would still see light from the surface of the star as it collapses, so the interior of a black hole isn't dark, at least until the star has finished collapsing.