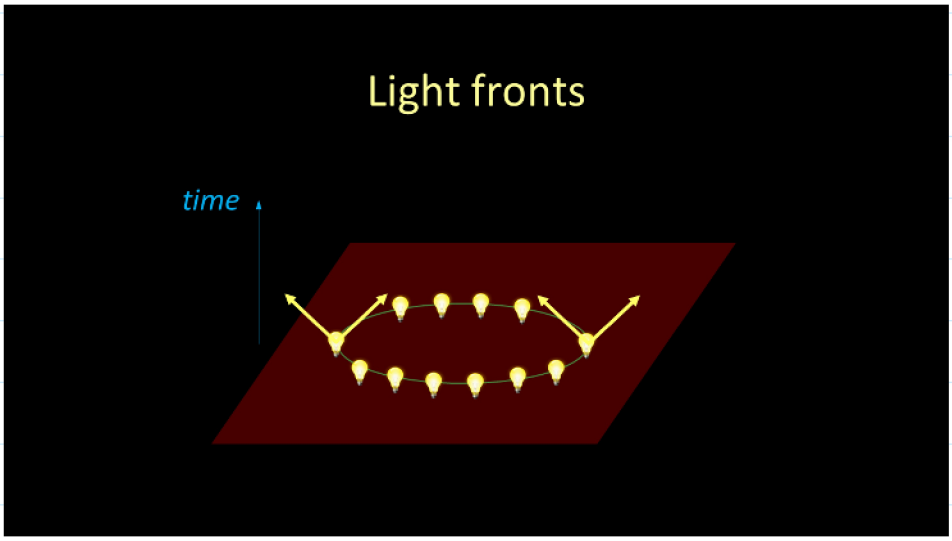
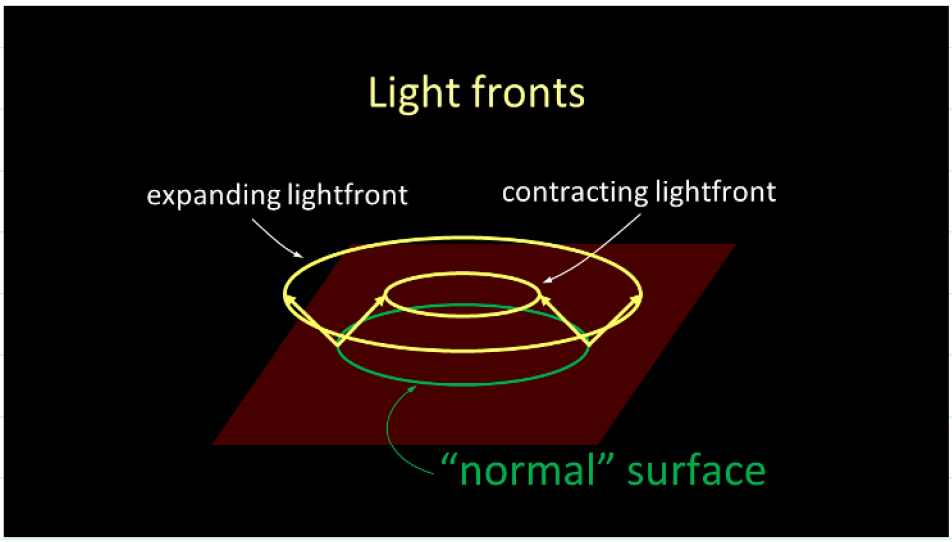
Lecture 1: Supplement II: Trapped surfaces, apparent horizon, and the singularity theorem

miércoles, 31 de agosto de 2022 17:54



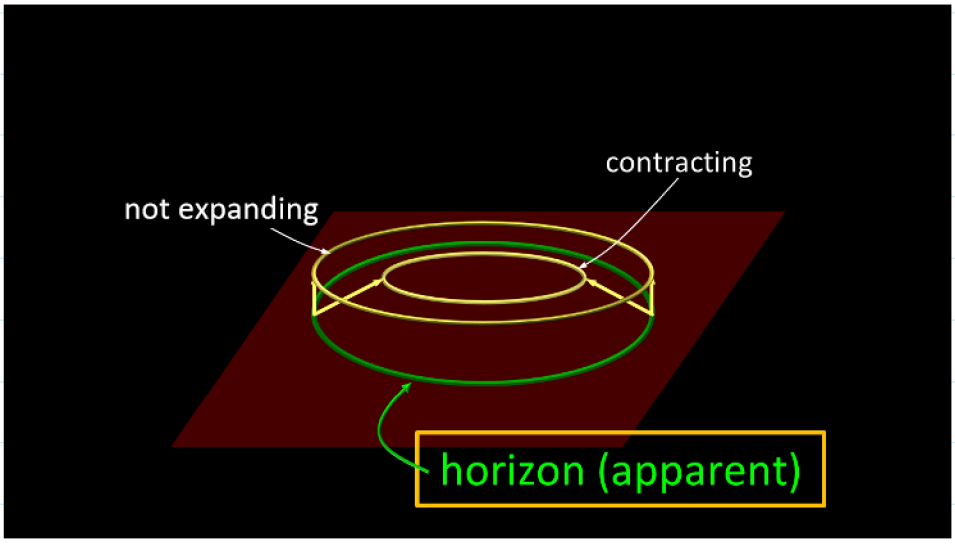
Distribute light bulbs on a closed surface (e.g. a sphere), and flash them at one moment in time.

Then, follow the light fronts that emanate from the surface.



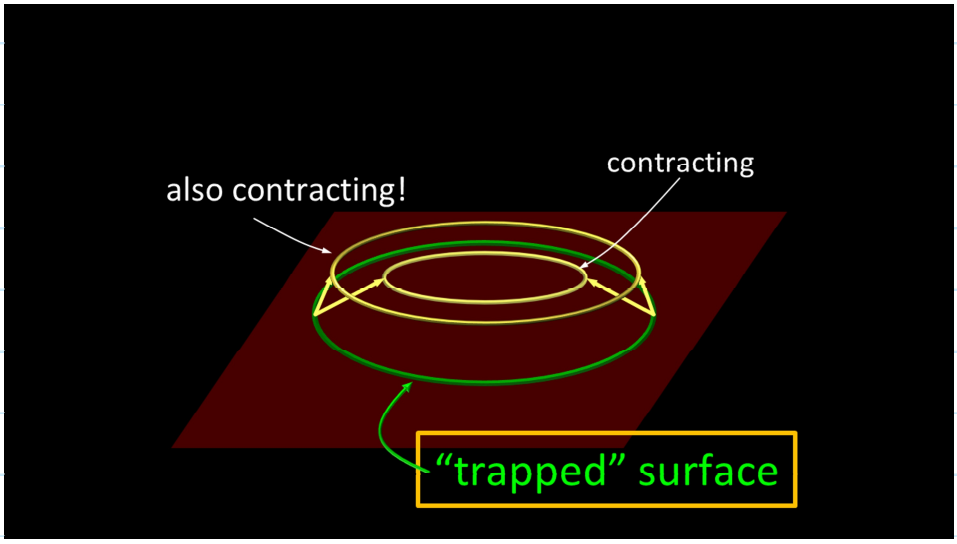
There will be light rays (and light fronts) that travel outward from the surface, and light rays that travel inward.

In a normal situation, the light fronts that travel outwards will expand, and those travelling inwards will contract

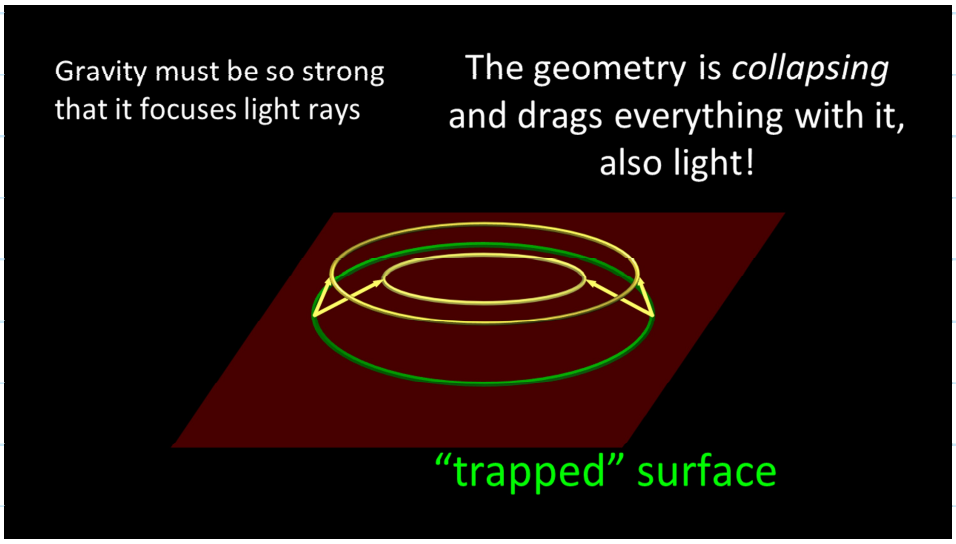


In some special situations where gravity is strong enough, the light fronts that are sent outwards do not expand.

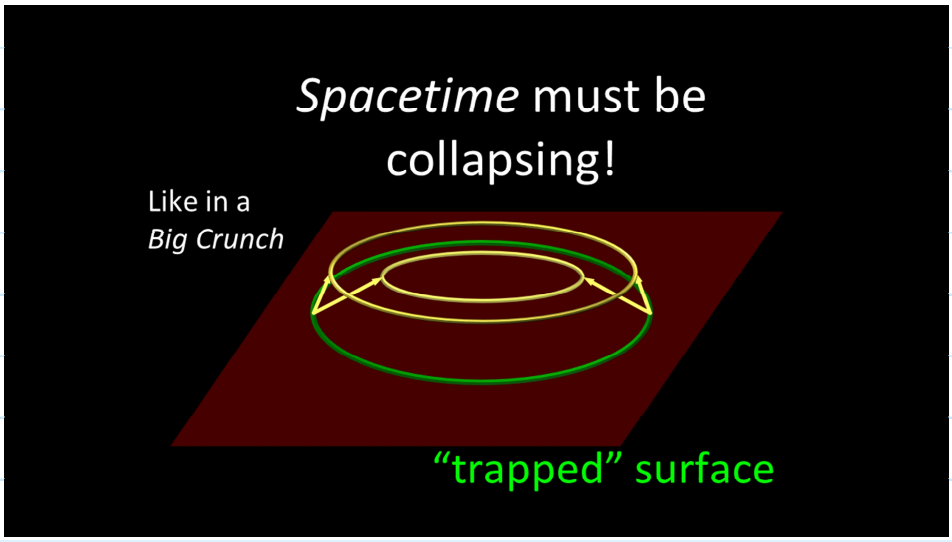
This is what happens in an **apparent horizon**

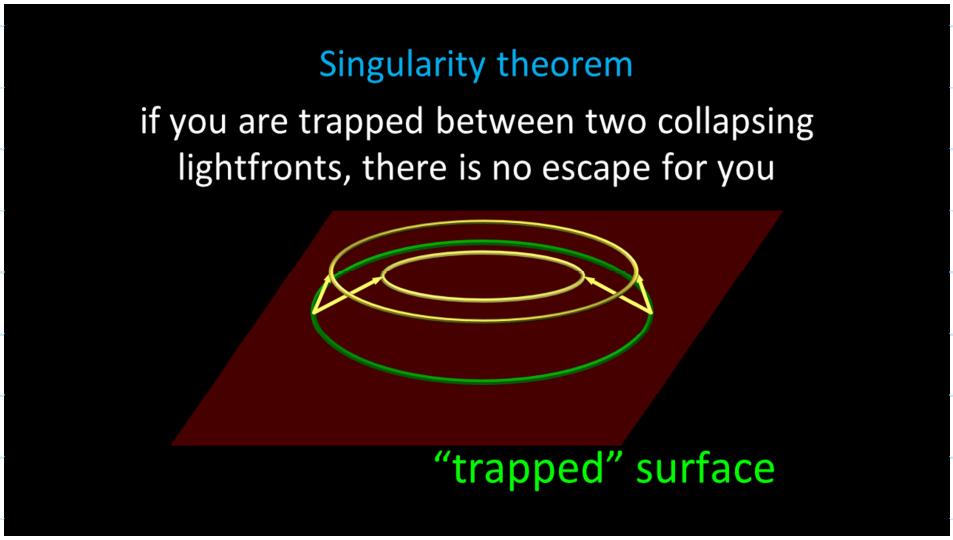


It may even be the case that the light fronts outgoing from the surface contract. In this case we say that the surface is **trapped**



The reason that outgoing lightfronts contract instead of expand is because the entire spacetime is collapsing, contracting so rapidly that everything, including lightfronts, collapses with it.





Penrose proved that the presence of trapped surfaces is an indicator of a collapse so strong that it will lead to a singularity in the future -- meaning an instant beyond which no predictions can be made using Einstein's theory

Penrose's singularity theorem

Assume that:

- Energy along null geodesics is non-negative (null energy condition)
- In a given non-compact time slice of the spacetime, there exists a compact trapped surface

Then:

- A singularity results at a finite time in the future -- that is, there must exist null geodesics that are incomplete, and therefore their evolution cannot be predicted using Einstein's equations