Bekenstein bound from the Pauli principle

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General facts

Bekenstein's argument that a black hole (BH) reaches the maximal entropy at disposal of a physical system[1] led to two main proposals:

- The degrees of freedom (dof) responsible for the BH entropy have to take into account both matter and spacetime and hence must be of a new, more fundamental nature than the dof we know, here we call such dof "Xons" [2]
- The Hilbert space $\mathcal{H}$ of the Xons of a given BH is necessarily finite dimensional[3]

[1] J. D. Bekenstein, Phys. Rev. D **23**, 287 (1981).
[2] G. Acquaviva, A. Iorio and M. Scholtz, Ann. Phys. **387**, 317 (2017).
[3] N. Bao, S. M. Carroll and A. Singh, Int. J. Mod. Phys. D **26**, no. 12, 1743013 (2017).

The model

Here[4] we reverse that logic. We suppose that

- In a BH only free Xons exist
- They are *finite* in number and *fermionic* in nature. This amounts to have a finite dimensional $\mathcal{H}$

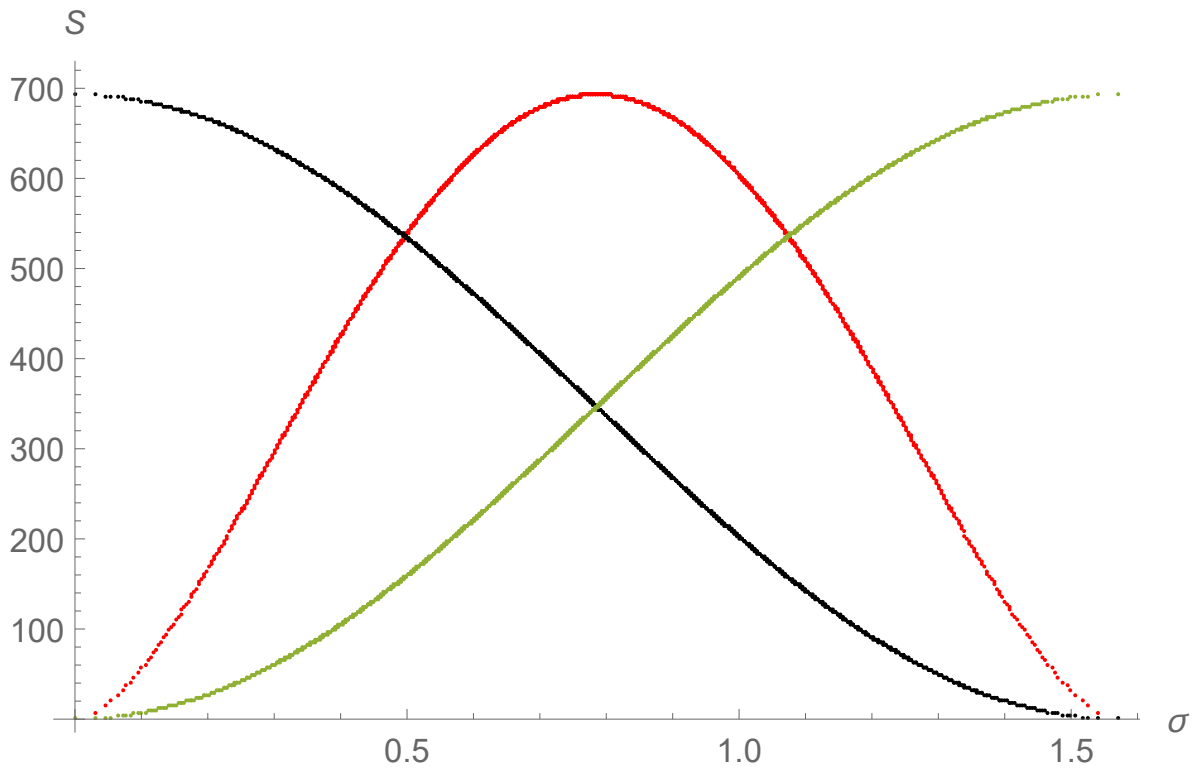
Then, one can show that BH evaporation is a dynamical mechanism producing a maximal entanglement entropy $\mathcal{S}_{max}$:

$$\dim \mathcal{H} \;=\; e^{\mathcal{S}_{max}} \tag{1}$$

[4] G. Acquaviva, A. Iorio and L. Smaldone,[arXiv:2005.13973 [hep-th]].

Entropies

$\mathcal{S}_{max}$ is equal to the initial *BH (decreasing) entropy* and to the final *environmental (increasing) entropy*:



These entropies are here described in a unifying scheme.