

# THE COINCIDENCE PROBLEM

**It is of the highest importance in the art of detection to be able to recognise out of a number of facts which are incidental and which vital.**

Arthur Conan Doyle (1893)

**Why are the matter and vacuum energy densities approximately equal today (the coincidence problem)?**

Sean Carroll (2001)

**Separating the important clues from the misleading coincidences is at the heart of scientific creativity.**

Manoj Kaplinghat & Michael Turner (2002)

**Why would a fundamental constant of nature, like the cosmological constant, be related to the matter density at the particular epoch when we humans happen to be around? The idea of some connection between these two quantities appeared totally ridiculous. The particle physics community was in disarray.**

Alex Valenkin (2006)

A while ago I bookmarked Carroll's paper. He wonders if Dark Energy and the Cosmological Constant  $\Lambda$  and the vacuum energy could all be the same thing. He's not the only physicist to see that this could be convenient. Like others, too, he finds their size coincidental. Like detectives he is not big on coincidence.

Is my fictional detective watching? He might want to look at two things side by side. Carroll regards  $\Lambda$  as an average density of energy. The Problem is: Why is the average density of matter more or less the same? Carroll sets it up in terms of timing:

At early times the vacuum energy was negligible in comparison to matter and radiation, while at late times matter and radiation are negligible. There is only a brief epoch of the universe's history during which it would be possible to witness the transition from domination by one type of component to another. ... It seems remarkable that we live during the short transitional period between these two eras.

Hoping my detective's tuned in, I find Carroll's Figure 1. It does look surprising. Of course it could be chance. But he thinks not. Someone may turn to that all-purpose pseudo-explanation, the Anthropic Principle. Carroll says it is 'by no means an economical solution.' I have no truck with it and yet I want to tell him Carroll's problem's no coincidence. But it seems I cannot tell him anything. Maybe he will figure this himself.

I have another take on timing. It's: Why does this transition happen as expansion of the universe is speeding up? This too, I want to say to him, could be coincidence. But it looks like a clue.