Hossenfelder Stagnation Problem

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Sabine Hossenfelder wrote an excellent blog posting about the growing awareness that outstanding scientific problems are not getting solved at the same rate as in the past. Her whole article is worth a read, as are all her postings, but this latest contained a mathematical statement that warranted justification.

The Present Phase Of Stagnation In The Foundations Of Physics Is Not Normal

Sabine Hossenfelder, November 19, 2018

(http://backreaction.blogspot.com/2018/11/the-present-phase-of-stagnation-in.html, retrieved 11/21/2018)

Nothing is moving in the foundations of physics. One experiment after the other is returning null results: No new particles, no new dimensions, no new symmetries. …

The current theories are incomplete. We know this both because dark matter is merely a placeholder for something we don't understand, and because the mathematical formulation of particle physics is incompatible with the math we use for gravity. Physicists knew about these two problems already in 1930s. And until the 1970s, they made great progress. But since then, theory development in the foundations of physics has stalled. …

This long phase of lacking progress is unprecedented. … quoting chronological time is meaningless. We should better look at the actual working time of physicists. …

According to membership data from the American Physical Society and the German Physical Society the total number of physicists has increased by a factor of roughly 100 between the years 1900 and 2000.[1] … And (leaving aside some bumps and dents around the second world war) the increase in the number of publications as well as in the number of authors is roughly exponential.

Now let us assume for the sake of simplicity that physicists today work as many hours per week as they did 100 years ago – the details don't matter all that much given that the growth is exponential. Then we can ask: **How much working time starting today corresponds to, say, 40 years working time starting 100 years ago. Have a guess! Answer: About 14 months.** Going by working hours only, physicists today should be able to do in 14 months what a century earlier took 40 years. …

We are today making more investments into the foundations of physics than ever before. And yet nothing is coming out of it. That's a problem and it's a problem we should talk about.

So the question is, how did Sabine Hossenfelder arrive at the 14 months?

Solution

First we need to make precise Hossenfelder's "working time" or "working hours" as a measure of the work effort. This is really the old "manhour" designation. That is, the amount of work that can be accomplished depends on the number of people working on the effort and the length of time

[1] (Hossenfelder:) That's faster than the overall population growth, meaning the fraction of physicists, indeed of scientists of general, has increased.

devoted to it. So we basically want to multiply the number of scientists times the length of time to define the work. Since the number of scientists is not constant and in fact grows exponentially, we have a calculus problem (Figure 1).

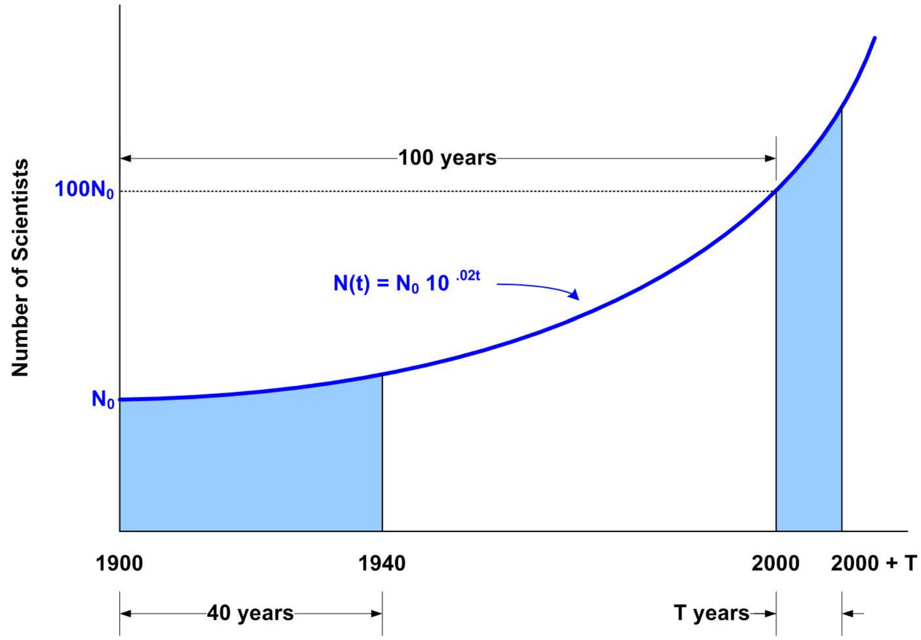

Figure 1 Scientific Work Effort (not to scale)

Using Hossenfelder's assumptions, if we have N_0 relevant scientists in 1900, then 100 years later in 2000 we have $100N_0$ scientists. As an initial simplification, we can express the exponential growth in powers of 10, that is, the number of scientists N at time t in years since 1900 can be given by

$$N(t) = N_0 10^{kt}$$

where k is a constant to be determined. Note when t = 0 (year 1900), $N(0) = N_0$. Now when t = 100 (year 2000), $N = 100N_0$. Therefore,

$$N(100) = N_0 10^{k100} = 100N_0 \Rightarrow 10^{k100} = 10^2 \Rightarrow k = .02$$

and so

$$N(t) = N_0 10^{.02t}$$

The problem is to find the time T since the year 2000 for which the work done over that period of time with the scientists available then equals the work done by the available scientists during the 40 years from 1900. So we want to find the T that gives equivalent areas under the scientist growth curve as shown in Figure 1.

Using calculus this means we want to find T such that

$$\int_0^{40} N(t)dt = \int_{100}^{100+T} N(t)dt$$

Notice that $N_1(t) = N(100 + t) = N_0 10^{.02(100 + t)} = 100N_0 10^{.02t}$. So we want to find T such that

$$\int_0^{40} N(t)dt = \int_0^{T} N_1(t)dt$$

or

$$\int_0^{40} N_0 10^{.02t}\,dt = \int_0^T 100 N_0 10^{.02t}\,dt$$

or

$$\int_0^{40} 10^{.02t}\,dt = 100\int_0^T 10^{.02t}\,dt$$

Now

$$\int_a^b 10^x\,dx = \int_a^b e^{(\ln 10)x}dx = \frac{1}{\ln 10}e^{(\ln 10)x}\Big]_a^b = \frac{1}{\ln 10}\left(10^b - 10^a\right)$$

Therefore we have

$$\frac{1}{\ln 10}\left(10^{.02\cdot 40} - 10^0\right) = \frac{100}{\ln 10}\left(10^{.02T} - 10^0\right)$$

or

$$10^{.8} - 1 = 100\,(10^{.02T} - 1) \;\Rightarrow\; 10^{.02T} = 1 + (10^{.8} - 1)/100 = 1.05309 \;\Rightarrow\; .02T = \log(1.05309)$$

so

$$T = 1.12327 \text{ years} \quad\Rightarrow\quad T = 13.48 \text{ months}$$