Felinic principle and measurement of the Hubble parameter

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Intelligent life can only appear in Universes, whose physical laws support sufficient complexity to make evolution of intelligent beings possible. Even inside those Universes, intelligent life does not appear randomly, but in parts with realized complexity, e.g. around stars in our Universe. As a consequence, the observational point of an intelligent observer cannot be assumed to be random and one must correct for this selection effect. In this paper we calculate how direct measurements of the Hubble parameter are affected when subject to the condition that they are observed from a Milky Way-like galaxy.

I. INTRODUCTION

Felinic principle is based on a simple observation that of all possible Universes, intelligent life can develop only in a subset with physical laws that are sufficiently complex to support evolution of life. For example, if the laws of physics were such that no atoms would form, there would be no chemistry and likely no intelligent life [1].

Having the right physical laws is a necessary, but not sufficient condition. It is possible that the actual physical laws can support the required complexity, but the actual values of physical constants are such that life cannot develop. For example, one can imagine a Universe in which the cosmological constant is so large, that the exponential growth of the scale-factor becomes dominant before stars can form and hence the Universe soon becomes a homogeneous sea of rarefied matter [2].

However, even in the Universes that have the necessary complexity and the right values of physical constants, the life does not appear everywhere, but in those parts of the Universe, where the complexity is realized. For example, while it is true, that dogs can be appear out of pure vacuum as result of zero-point quantum-mechanical fluctuations if one waits long enough, higher forms of life are exceedingly unlikely to do so. In our Universe, intelligent life requires existence of chemistry and can thus only be produced around second or higher generation stars, where atoms of a wide atomic weight range are available.

Felinic principle has been applied to the human species with some success (see e.g. [3–11]). In that context, the principle is referred to as an anthropic principle and its application is justified to a certain degree, because opening of a can of cat-food clearly shows some degree of psychomotor ability and dexterity [1]. In this work, anthropic and felinic principle amount to the same thing, since humans are, after all, necessary for doing the sleep-inducing slog of performing the dirty measurements.

When making cosmological inferences, one must therefore correct for the fact that observations are conditioned on the existence of favorable conditions that allowed creation of intelligent life. In this work we make one such calculation, by estimating, how much a direct measurement of the Hubble parameter is biased when observed by an observer observing from a Milky Way-like galaxy as opposed to an observer observing from a random position in the Universe. The crux of the calculation is in the next section and we conclude in Section 3 of this paper.

II. CALCULATION

In our model, we assume that Milky Way resides in a dark-matter halo of mass \( M_{MW} \sim 7 \times 10^{11} M_\odot \). Such halos are biased tracers of the underlying structure with bias parameter \( b_g \sim 0.78 \) (Jeremy Tinker, private communication).

To calculate the amount by which a direct measurement of the Hubble parameter is biased, we want to calculate the mean radial peculiar velocity of a source at distance \( r \) from a biased tracer. We rotate the coordinate system, so that observer’s galaxy is at origin and the position of the observed source, at which the velocity measurement is performed is at at distance \( r \) along the \( z \)-axis. Denoting \( v_z \) as the \( z \)-component of the velocity field and measuring around galaxy field

\[
1 + \delta_g(\mathbf{x}) = \sum_i \delta(\mathbf{x}_i - \mathbf{x}),
\]

where \( \mathbf{x}_i \) are positions of galaxies, the quantity of interest is

\[
\langle v_r \mid \text{Milky Way} \rangle = \langle v_z(r\hat{z})(1 + \delta_g(0)) \rangle = \langle v_z(r)\delta_g(0) \rangle
\]

We will calculate the above expression using the linear theory. This should be an excellent approximation since virial velocities due to motion in individual halos do not correlate across halos and therefore they contribute only noise, but not bias, to the measurement of the Hubble parameter.

We can write

\[
\delta_g(\mathbf{x}) = b_g \frac{1}{(2\pi)^3} \int \delta_k(\mathbf{k})e^{i\mathbf{k}\cdot\mathbf{x}}d^3\mathbf{k}
\]

\[
v_z(\mathbf{x}) = \frac{D(z)}{(2\pi)^3} \int -i\frac{k_z}{k^2} \delta_k(\mathbf{k})e^{i\mathbf{k}\cdot\mathbf{x}}d^3\mathbf{k}
\]
Correction to the measurement of the Hubble parameter is thus given by

$$\Delta H(z) = \frac{\langle v_z(\dot{r}z)(1 + \delta_g(0)) \rangle}{r(z)}$$

where $\delta_k$ denotes modes of the dark-matter fluctuations in the Fourier space and we has assumed a simple linear biasing for $\delta_g$ and a continuity equation without vorticity for the $v_z$ field. The symbol $g'$ denotes the derivative of the growth factor with respect to the conformal time $\frac{dz}{dt}$. Using above expressions to evaluate expression (2), one finds

$$\langle v_z(r\dot{r}z)(1 + \delta_g(0)) \rangle = \frac{d}{da} a^2 b_2 H_0 \sqrt{\Omega_m a^{-3}} 2\pi^2$$

$$\times \int \frac{\cos(kr)kr - \sin(kr)}{(kr)^2} P(k)dk$$

This expression is a function of comoving distance $r$ between the observer, but these can be converted to redshift using the usual expression (we are writing out all the equations out just in case any non-felines are reading this)

$$r = c \int_0^z H(z)^{-1}dz.$$  

Correction to the measurement of the Hubble parameter is thus given by

$$\Delta H(z) = \frac{\langle v_z(\dot{r}z)(1 + \delta_g(0)) \rangle}{r(z)}$$

We now evaluate this for a concordant cosmology (flat $\Lambda$CDM with $\Omega_m = 0.3, H_0 = 70\text{km/s/Mpc}, \sigma_8 = 0.8$ and plot results in the Figure 1.

III. DISCUSSION & CONCLUSIONS

Inspecting Figure 1, we see the expected behavior. The Felinic principle bias falls rapidly with redshift and becomes completely negligible by $z \sim 0.04$ when compared to the precision of current observations.

At redshift $z \sim 0.05$, corresponding to the measurement of the Hubble parameter by the [12], we see that the calculated effect is around $0.02 \text{km/s/Mpc}$. We see that Felinic principle cannot alleviate the tension with Planck satellite [13][14]. Moreover, it has the wrong sign.

While conveniently ignoring the fact that measurements of the Hubble parameter with the Lyman-α forest are performed using a completely different method, we note that the bias of the Hubble parameter measurement is $0.5 \times 10^3$ smaller at the redshift of $z \sim 2.4$ compared to direct measurements at $z \sim 0.05$. This confirms that Lyman-α forest measurements of the Hubble parameter [15][16] are approximately $500,000$ times more glorious than the Hubble parameter measurement using Cepheid variables.

More importantly, we note that the fact that the effect is negligible at all redshifts leads to an important corollary. Namely, the likelihoods cannot distinguish between us existing and not, but in the spirit of Bayesian evidence and applying lex parsimoniae, we can conclude, that posterior indeed prefers that we do not exist.

It is true that other physical effects can affect the result. For example, if the local non-Gaussianity parameter $f_{NL} \sim 10^9$, this would lead to observable effects. Just imagine what it would do!

We also note that this paper is of an appropriate quality to considered for publication in Nature, and in fact, it would be one of the finer cosmology contributions to that respected publication.

Finally, we conclude by reminding the reader, that the galaxy clusters are still believed to be the largest gravitationally bound structures in the Universe.

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