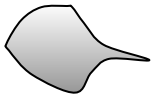
hubble-maths

23.01.2024

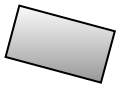
The shape of our universe

1

The “Hubble-Maths” – that is the mathematic about the Hubble-Parameter – determines the shape of our universe. That is the reason why the so called Hubble-Paramer is important – at least if we want to know *where* we live. Because the Hubble-Parameter finally shows if our universe is hyperbolic open, if it is euclidian flat, or if it is spherical closed.



hyperbolic open
negativ curvature



euclidian flat
no curvature

spherical closed
positiv curvature

Today we know that the universe is approximately “euclidian flat”. But only *approximately* – not exactly. In order to know it exactly we need to measure the Hubble-Parameter very accurately.

And right here we have a discrepancy: Two different methods of measuring reveal two different **not** agreeable values.

Ok, “*that just happens*” you could say. But that is not the case: Both values are very exact and very clear – but just different. This difference states that we just did not understand everything. Something in today’s physics is wrong. The standard-modell of today’s physics (Quantum-field-theory + The Particle Modell + General Theory of Relativity) has at least a gap.

This “gap” adds up to the other unanswered big questions:

What is “dark matter”?

What is “dark energy”?

And now we also have:

What causes the Hubble-Discrepancy?

The next chapters give a short overview over the mathematical dependencies which are associated with the Hubble-discrepancy.

Hubble-Parameter

2

The Hubble-parameter shows the speed of far away galaxies. These galaxies move away from us. The Hubble-parameter is defined here:

Hubble-Parameter	$H_0 = \frac{v}{d}$	v = Velocity of a galaxy d = Distance of a galaxy H_0 = Proportionality at the time „today“ Hubble-Parameter or Hubble-Constant

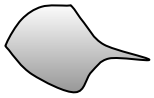
In fact all galaxies move away from us. We notice this if we measure the red-shift of the light from the galaxies. The bigger the distance of a galaxy the faster it is moving away from us.

We here on earth are not the center of the universe. And that means: Everything moves away form each other. So we can see that the whole universe must be expanding. The Hubble-parameter tells us the amount of the expansion.

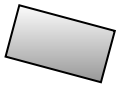
Form

3

Depending on the total mass (and energy) of the universe it has a specific form. This is a result of the General Relativity. The form of the unverse can be:



hyperbolic open
negativ curvature
infinite



euclidian flat
no curvature
infinite

spherical closed
positiv curvature
finite

critical density ρ_c

If the total mass results into the critical density ρ_c then exactly the universe is flat.

Critical density ρ_c

4

The critical density ρ_c can be calculated from the Hubble-parameter:

$$\rho_C = \frac{3\ H^2}{8\ \pi\ G}$$

critical density ρ_c
means:
gravitation and vacuum-energy are in an equilibrium

G: gravitational constant

For a better imagination we invent the Density-parameter Ω. This parameter shows how close we come to the „critical density“ ρ_c for a flat universe. Here ρ is the currently measured density of the universe.

Density - parameter

$$\Omega = \frac{\rho}{\rho_c}$$

$\Omega = 1$	steady state universe
$\Omega < 1$	expanding universe
$\Omega > 1$	contracting universe

The Total Density Ω is the sum of the single matter-energy types:

visible matter | dark matter | vacuum energy

$$\Omega = \Omega_{vm} + \Omega_{dm} + \Omega_v$$

$\Omega \sim 1$ The universe is approximately „flat“.

Currently we assume that our universe is approximatley flat. This assumption is expressed by a Total Density Ω being approximately one. So we write: $\Omega \sim 1$.

The whole content of the universe adds up, so that the critical density ρ_c is matched, i.e. $\rho = \rho_c$ and thus $\Omega = 1$. The dark matter contributes $\Omega_{dm} \sim 0.25$, the dark energy contributes $\Omega_v \sim 0.70$. The normal matter, which we know, and which we can see, has a fraction of $\Omega_{vm} = 0{,}05$ only. So all what we can see are only 5% of the content of the universe!

Hubble-measurement

5

All in all this is slightly confusing. We assume that the universe is nearly flat. This is the reason why we write $\Omega \sim 1$. In order to find out how the universe looks like exactly we have to measure the Hubble-parameter as good as possible. Just because that value determines the critical density ρ_c.

We did this in two different ways:

In april 2022 the team around Adam Riess published very exact data derived from the hubble-telescope measurements. Here the distance is calculated with the help of the Cepheides and by supernovas of type 1a. The velocity is directly measured from the red shift of the spectrum. The team of Adam Riess determined the Hubble value to be 73.04 +-1.04 km/s per Megaparsec.

The other measurement was done with the Planck Telescope by the “Planck Collaboration”. They measured the Microwave Background CMB very exactly. The Hubble parameter can be deduced from the photon fluctuations. The “Planck Collaboration” published the value 67.36 +- 0.54 km/s per Megaparsec already in 2020.

We see that the uncertainty interval is so small that we can say:
Both measurements do **not** match!

So the measurement of the Hubble-Parameter reveals two different values:

method	result
Direct measurement of the red shift	73 km/s per Megaparsec
CMB– measurement by the Planck-Satellite	67 km/s per Megaparsec

CMB = Cosmic Microwave Background

This discrepancy cannot be explained today.
It is one of the „big“ mysteries.

This discrepancy between both measurements is currently (2024) not comprehensible. It cannot be understood. We can exclude a lack of exactness. We also can exclude any systematical mistakes made at the evaluation.

What is left is the explanation that anything in our comprehension of nature is (still) wrong. For now this is a big puzzle. It is a mystery!