Eureka Proposal — Redshift reduction telescope

Shashank Bodapati   Daksh Jain   Shivansh Malhan

Ahaan Shokeen

2026-01-06

Theme 3: Intelligent Systems (Robotics, Coding and Machines)

Name	Grade and Section	Role
Bodapati, Shashank	7B	Prototyper
Jain, Daksh	7D	Researcher
Malhan, Shivansh	7A	Presenter
Shokeen, Ahaan	7A	Documenter

1 Problem Statement

We want to address the problem of cosmological redshift and blueshift. This is a problem because whilst astronomers can use software to correct for redshift and blueshift (hereon referred to as RSBS), it is cumbersome to obtain the image and then correct it. Our product aims to be an all-in-one tool; a telescope that colour-corrects for RSBS, analyses the images to compare them with images of known, catalogued galaxies; to obtain the distance, obtains the velocity, obtains the redshift z; negative values are blueshift, and positive values are redshift. This process is carried out through a Raspberry Pi 4, which is a powerful computer that can be programmed through Python.

2 Background Research

2.1 Mathematics

In our project, we have used the physical concepts of special relativity, Hubble's law, cosmological expansion, redshift and blueshift, and the computer science concept of programming. These shall be applied into the product through

programming, i.e., we shall program the computer to account for these effects, such as adjusting for relativity and colour-correcting the images, using OpenCV, a Python library that is good at editing images through code. To demonstrate this, some mathematics follows:

Converting H_0 to SI units (we do not want to make *that* mistake again):

$$H_0 \approx 69.8\,\mathrm{km\,s^{-1}Mpc^{-1}} = \frac{69.8 \cdot 10^3}{10^6(3.09 \cdot 10^{16})} = \frac{69.8 \cdot 10^3}{3.09 \cdot 10^{22}} \approx 2.23 \cdot 10^{-18}\,\mathrm{s^{-1}}$$

Using the formula for a galaxy 40 Ym away with an emitted wavelength of 620 nm:

$$v = H_0 \cdot d \Rightarrow v = (2.23 \cdot 10^{-18})(4 \cdot 10^{25}) = 8.92 \cdot 10^7\,\mathrm{m\,s^{-1}}$$

Because we are dealing with speeds close to the speed of light, we cannot use the simple Doppler formula $z = \frac{v}{c}$. Hence, we must use the full relativistic formula:

$$z = (1 + \frac{v}{c})\gamma - 1.$$

γ, the Lorentz factor, is approximately 1 for all $v \ll c$, but since this galaxy is receding at a speed close to the speed of light, we must calculate it through:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}.$$

Now, substituting that into the original formula:

$$z = (1 + \frac{v}{c})\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1$$

Finally, we can substitute our own values into the formula:

$$z = (1 + \frac{8.92 \cdot 10^7}{3 \cdot 10^8})\frac{1}{\sqrt{1 - \frac{(8.92 \cdot 10^7)^2}{(3 \cdot 10^8)^2}}} - 1 \approx 0.359$$

Hence, the observed wavelength is calculated by $\lambda_{obs} = \lambda_{emit}(1 + z)$:

$$\lambda_{obs} = (6.2 \cdot 10^{-7})(1 + 0.359) \approx 8.43 \cdot 10^{-7}\mathrm{m} = 843\,\mathrm{nm}$$

This shifts the visible red light into the infrared spectrum. Our telescope then reverses this process to reconstruct the original image.

2.2   Extant solutions

Solutions to this that are currently present include:

- Manual computer processing after image capture

- Manually using formulae to reconstruct image

The underlying problem is the lack of convenient conversion. If the above calculations were to be carried out through an integrated computer that displayed the image relatively quickly, it would be easy to obtain a nice view of the observable universe.

3 Design Brief

The intended solution is not to eliminate redshift; to be explicit. Eliminating cosmological redshift would involve stopping the expansion of the universe, which is extremely impractical and difficult to perform. The solution is a software-based, built-in reconstructing telescope that estimates the recessional velocity of the viewed electromagnetic radiator utilizing a database of catalogued galaxies accessible via the Internet or a manually entered distance. This solution targets astronomers, cosmologists, and hobbyists; although astronomers and cosmologists have other tools for this, a hobbyist may not. The goal is to, as Jain said, "enhance our *interpretation* of it to the extent that it's not distinct." Reiterating the opening statement, we do not intend to eliminate redshift, we intend to colour-correct it.

4 Challenges and Fallacious Mathematics

4.1 Forgetting SI unit conversion

These can be demonstrated through a mathematical example for a galaxy with real wavelength 620 nm and a distance of 400 Pm:

$$v = H_0 \cdot d \Rightarrow v \approx 69.8(4 \cdot 10^{17}) = 2.792 \cdot 10^{19} \, \text{m s}^{-1}$$

Because we are dealing with speeds faster than the speed of light, we cannot use the simple Doppler formula $z = \frac{v}{c}$. Hence, we must use the full relativistic formula:

$$z = (1 + \frac{v}{c})\gamma - 1.$$

γ, the Lorentz factor, is approximately 1 for all $v \ll c$, but since this galaxy is receding faster than the speed of light, we must calculate it through:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}.$$

Now, substituting that into the original formula:

$$z = (1 + \frac{v}{c})\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1$$

Finally, we can substitute our own values into the formula:

$$z = (1 + \frac{2.792 \cdot 10^{19}}{3 \cdot 10^8}) \frac{1}{\sqrt{1 - \frac{(2.792 \cdot 10^{19})^2}{(3 \cdot 10^8)^2}}} - 1 = (9.3067 \cdot 10^{10}) \frac{1}{\sqrt{-9.3067 \cdot 10^{10}}} - 1$$

$$= (9.3067 \cdot 10^{10}) \frac{1}{305068.2984} i - 1 = \frac{9.3067 \cdot 10^{10}}{305068.2984} i - 1 = 305068.2984i - 1$$

$$= -1 + 305068.2984i$$

Interesting, a complex redshift! This is physically impossible, because i is *imaginary*, but the reason for this error is because we have forgotten to convert H_0 into SI units. It was quite funny when we discovered we had complex redshift, because, well, that means the galaxy is outside the Hubble Horizon and pulling the light back with it.

Works Cited

Einstein, Albert. "On the Electrodynamics of Moving Bodies." *Annalen der Physik*, vol. 322, no. 10, 1905, pp. 891–921.

Hubble, Edwin. "A Relation between Distance and Radial Velocity among Extra-Galactic Nebulae." *Proceedings of the National Academy of Sciences*, vol. 15, no. 3, 1929, pp. 168–173.

"Planck 2018 Results. VI. Cosmological Parameters." *Astronomy & Astrophysics*, vol. 641, 2020, p. A6.

Raspberry Pi 4 Model B Product Brief. Raspberry Pi, Jun. 2019, `https://datasheets.raspberrypi.com/rpi4/raspberry-pi-4-product-brief.pdf`

Jain, Daksh. Zoom messaging with the group. 21 Dec. 2025.