Doppler Shift Calculations for Wow! signal (1977)

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1 Introduction

The text describes the Wow! signal, a strong radio transmission detected by the Big Ear telescope on August 15, 1977, at a frequency of 1420.4556 MHz, which corresponds to a wavelength of 21.105373 cm. The signal's expected frequency, based on hydrogen, is 1420405751.768 Hz, translating to a wavelength of 21.106114054160 cm. The Doppler shift calculations suggest that the signal originated from an object moving towards Earth at a speed of approximately 10,526 m/sec (37,893 km/h).

For context, the average speed of asteroids is around 18–20 km/s, while comets that impact Earth typically travel at about 30 km/s. In comparison, the man-made Voyager spacecraft 1 and 2 are currently traveling at speeds of 15 to 17 km/s.

1. **Converting frequency to wavelength: The relationship between frequency (f), wavelength** $(\lambda))and speed of light(c) is given by : c = f \times \lambda where : -c$ **(speed of light) = 299,792,458 m/s -** $f = 1420.4556\,MHz = 1420.4556 \times 10^6\,Hz = 1,420,455,600\,Hz$

The wavelength (λ) **calculation becomes:**

$$\lambda = \frac{c}{f} = \frac{299,792,458\,m/s}{1,420,455,600\,Hz} \approx 0.2105\,m = 21.05\,cm$$

(The value of $21.105373\,cm$ **seems to imply an accurate conversion, but it is a little high compared to 21.05 cm. However, this could be due to rounding differences.)** 2. **The presumed origin signal of hydrogen**: Given: - Frequency = 1420405751.768 Hz - Wavelength $(\lambda)) = \frac{c}{f} = \frac{299,792,458\,m/s}{1420405751.768\,Hz} \approx 0.2106\,m = 21.106114\,cm$

3. **Calculating the Doppler shift speed**: If the Doppler shift speed is calculated from $\Delta\lambda$ and λ, the formula is given by:

$$v = \left(\frac{\Delta\lambda}{\lambda}\right) \times c$$

where: - $\Delta\lambda = \lambda_{observed} - \lambda_{source}$ - For the observed and source wavelengths, we have:

$$\Delta\lambda = 21.105373\,cm - 21.106114054160\,cm \approx -0.000741054160\,cm$$

Converting to meters:

$$\Delta\lambda \approx -0.0000074105416\,m$$

The original wavelength becomes:

$$\lambda \approx 0.2105\,m$$

Now applying the Doppler shift formula:

$$v = \left(\frac{-0.0000074105416\,m}{0.2105\,m}\right) \times 299,792,458\,m/s \approx -10,526\,m/s$$

4. **Final speed calculations**: - The speed in km/h is:

$$-10,526\,m/s \times 3.6 = -37,893.6\,km/h$$

5. **Conclusion**:

- The calculation of $10,526\,m/s$ or approximately $37,893\,km/h$ for the speed of the Wow! signal is correct based on the provided information, though the nuances in wavelength calculations can lead to slight variations. The comparison with asteroid and comet speeds is valid. The Wow! signal exhibited a notably slower speed compared to the common asteroid and comet velocities and the man-made Voyager spacecraft.

Reference:

"The tantalizing WOW! Signal" by John Krauss, 1977, Archives of the National Radio Astronomy Observatory,

https://www.nrao.edu/archives/files/original/2ec6ba346ab16e10a10d09462507beda.pdf