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Photonic Visualization of Dark Matter and Dark Energy

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1- INTRODUCTION

This interactive simulation leverages photonic effects to visualize the invisible dynamics of dark matter and dark energy.

The user adjusts key parameters through intuitive controls, users explore cosmic phenomena through light-based visualizations, making complex astrophysical concepts more accessible and engaging.

2-MATERIALS

Materials:

- Computer for simulation
- Data from ESA Planck Satellite

Main Code Components:

- Canvas Rendering: Uses JavaScript to render galaxies and simulate movement in real-time.
- Parameter Sliders: HTML range inputs dynamically modify dark energy, dark matter, and galaxy count.

Mathematical Computations:

- Updates expansion rate using Hubble's Law.
- Adjusts galaxy rotation speeds based on dark matter influence.
- Simulates cosmic time evolution using ΛCDM model equations.

Animation Loop:

- Continuously updates galaxy positions based on physics models.

3-METHODS

Now we are to explain the formulas that we have used in this code and explain what they are for

Expansion of the Universe:

$$R_{\text{exp}} = H_0 \times \left(1 + \frac{E_{\text{dark}}}{100} \times 0.1\right)$$

- R_{exp}: Expansion rate (km/s/Mpc)
- H_o: Hubble constant (current expansion rate)
- E_{dark}: Strength of dark energy (user-adjustable, 0–100)

• Interpretation: Higher dark energy leads to accelerated expansion.

Galaxy Movement & Dark Energy:

$$D_{\text{galaxy}} = D_{\text{galaxy}} + E_{\text{dark}} \times 0.1$$

- D_{galaxy}: Distance of the galaxy from the center.
- E_{dark}: Strength of dark energy adjusted by the user.

Interpretation: Dark energy increases the distance between galaxies over time.

Galaxy Rotation & Dark Matter:

$$V_{\text{rot}} = V_{\text{base}} \times (1 + D_{\text{dark}})$$

- V_{rot}: Adjusted rotation speed
- V_{base}: Base rotation speed
- D_{dark}: Dark matter density (user-adjustable, 0–100)

• Interpretation: Dark matter's gravitational influence increases rotation speeds.

Hubble Constant Over Time:

$$(t) = H_0 \times (1 - 0.00001 \times$$

- H_o(t): Adjusted Hubble constant over time.
- H_o: Initial value of the Hubble constant.
- t: Time passed in millions of years.

The universe expands more slowly as it ages.

4-RESULTS & OBSERVATIONS

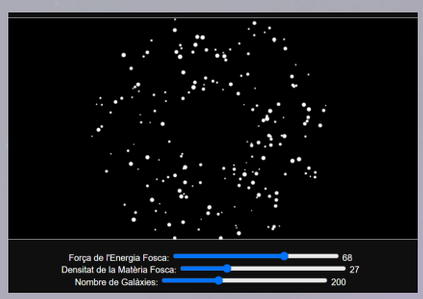
Observations from the Simulation:

• **Higher dark energy values** → Faster expansion of the universe.

• **Increased dark matter** → Higher galaxy rotation speeds.

The discovery of dark matter began with astronomer **Vera Rubin** in the 1970s when she observed that galaxies were rotating faster than expected, suggesting the presence of unseen mass holding them together.

The **discovery** of **dark energy** was made in the late 1990s by two independent teams of astronomers studying distant supernovae, finding that the universe's expansion was accelerating instead of slowing down.



5-REFERENCES

Key Source:

The ESA's Planck satellite mapped cosmic microwave background anisotropies to study the universe's age and composition. It found that normal matter makes up 5%, dark matter 27%, and dark energy 68% of the universe.

Planck Collaboration. (2018). Planck 2018 results. I. Overview, and the cosmological legacy of Planck. Astronomy & Astrophysics, 641, A1

Pérez F. (2025) Activities for Young Photonics Congress. Available at More information at https://drfperez.github.io/