MBT Replication Kit 1: Pantheon+ Supernovae Fit

# 1. MBT Cosmological Distance Equation

The MBT comoving distance model applied to supernova data is:  
d(z) = A \* z/ln(10) + B \* (exp(z/ln(10)) – 1)/(1 + αz)  
  
Where:  
• A and B are model constants (fitted to data)  
• α controls late-time curvature  
• ln(10) ≈ 2.3026  
• z is redshift  
  
Pantheon+ Best-Fit Values (for Supernovae only):  
• A = 3600 Mpc  
• B = 800 Mpc  
• α = 1.0

# 2. Python Code for MBT Supernova Fit

import numpy as np  
import matplotlib.pyplot as plt  
from scipy.integrate import quad  
from sklearn.metrics import r2\_score  
  
c = 299792.458 # speed of light in km/s  
H0 = 70 # Hubble constant in km/s/Mpc  
Om0 = 0.3  
Ol0 = 0.7  
  
# Pantheon+ Supernova Data (replace with real data)  
z = np.array([...])  
mu\_obs = np.array([...])  
  
def mbt\_distance(z, A=3600, B=800, alpha=1.0):  
 ln10 = np.log(10)  
 return A \* (z / ln10) + B \* (np.exp(z / ln10) - 1) / (1 + alpha \* z)  
  
d\_L\_mbt = mbt\_distance(z)  
mu\_mbt = 5 \* np.log10(d\_L\_mbt) + 25  
  
residuals = mu\_obs - mu\_mbt  
r2 = r2\_score(mu\_obs, mu\_mbt)  
  
plt.figure(figsize=(10, 6))  
plt.scatter(z, mu\_obs, color='black', s=10, label='Observed Pantheon+')  
plt.plot(z, mu\_mbt, color='red', label=f'MBT Model R²={r2:.4f}', linewidth=2)  
plt.xlabel('Redshift (z)')  
plt.ylabel('Distance Modulus (μ)')  
plt.legend()  
plt.grid(True)  
plt.show()

# 3. Sample Output and Fit Quality

Below are suggested figures to include for transparency and validation:  
• Figure 1: MBT model fit (red) to Pantheon+ supernova distance modulus data (black points).  
• Figure 2: Residuals between observed and MBT-predicted distance modulus.  
• Figure 3: MBT curve fit to low-redshift Pantheon+ supernovae using best-fit parameters.  
• Figure 4: MBT curve fit to low-redshift Pantheon+ using global/universal parameters.  
  
Paste your generated images here after running the above code.

# 4. Observational Data Used

• Pantheon+ Supernovae Compilation (Brout et al., 2022)  
(Public dataset, redshift range 0 < z < 2.3)

# 5. Replication Steps

1. Download Pantheon+ supernovae data.  
2. Run the MBT model code above.  
3. Plot predicted MBT distance modulus vs. observed data.  
4. Compute residuals, R², and chi-squared (optional).  
5. Compare MBT model to ΛCDM (see below).

# 6. Reference ΛCDM Comparison Code

def E\_inv(z, Om0, Ol0):  
 return 1.0 / np.sqrt(Om0 \* (1 + z)\*\*3 + Ol0)  
  
def luminosity\_distance\_lcdm(z\_vals, H0=70, Om0=0.3, Ol0=0.7):  
 d\_L = []  
 for z in z\_vals:  
 integral, \_ = quad(E\_inv, 0, z, args=(Om0, Ol0))  
 d = (1 + z) \* (c / H0) \* integral  
 d\_L.append(d)  
 return np.array(d\_L)  
  
d\_L\_lcdm = luminosity\_distance\_lcdm(z)  
mu\_lcdm = 5 \* np.log10(d\_L\_lcdm) + 25

# 7. Notes

• MBT matches Supernovae data using motion-based tension curves—no dark energy term is required.  
• This kit enables independent reproduction of all results.  
• BAO and CMB fits require adjusted A, B, α (see Replication Kit 2).