Section 9: Phase Cosmology

The Geometric Theory of Phase (GPT) offers an alternative cosmological framework that seeks to explain the large-scale structure and evolution of the Universe through the dynamics of the phase background, without resorting to the concepts of geometric expansion of space, dark matter, or dark energy in their standard forms.

9.1 Dynamic Universe without Geometric Expansion:

- GPT posits that the Universe's evolution is not characterized by the metric expansion of spacetime fabric as in the ΛCDM model. Instead, cosmic evolution is described as a change in the state of the global Phase Background over time.
- **Evolution of the Background ($T_0(t), a_{phase}(t)$):** A key hypothesis is that as structures (phase vortices representing matter) form and evolve, the average equilibrium phase tension of the background, T_0, may change over cosmological timescales. This could be a "cooling" of the phase background (decrease in T_0) or a change in its effective "density" or "viscosity."
- This evolution can be characterized by a **phase scale factor**, $a_{phase}(t)$. Unlike the metric scale factor in standard cosmology, $a_{phase}(t)$ does not describe the stretching of space itself. Instead, it might represent the inverse of the average background tension ($a_{phase}(t) \sim 1/T_0(t)$) or a characteristic length scale related to the average separation of large-scale phase structures or the coherence length of phase fluctuations. The dynamics of $a_{phase}(t)$ would be governed by global phase energy-momentum conservation principles, forming a phase-analog to the Friedmann equations.

9.2 Cosmological Redshift (z):

GPT offers alternative mechanisms for the observed cosmological redshift of distant objects, which do not rely on the Doppler effect due to spatial expansion:

- **Mechanism 1: Phase Drift in an Evolving Background (Original GPT Hypothesis):**
  - If the background tension $T_0(t)$ evolves (e.g., decreases with cosmic time), a photon (a phase vortex) emitted in the past when the background was "hotter" (higher $T_0(t_{em})$) would gradually lose energy as it traverses the "cooling" background. Its phase vortex structure "relaxes," and its wavelength increases, leading to a redshift.
  - The redshift z would be related to the change in background tension: $1+z = \frac{E_{em}}{E_{obs}} \approx \frac{T_0(t_{em})}{T_0(t_{obs})}$. If $T_0 \propto 1/a_{phase}^k$, then $1+z \approx \left(\frac{a_{phase}(t_{obs})}{a_{phase}(t_{em})}\right)^k$. This can mimic the Hubble-Lemaître law.
- **Mechanism 2: "Light Fatigue" Modulated by Local Environment (Alternative Static Background Hypothesis):**
  - This more recent hypothesis within GPT suggests a globally static background T_0. Redshift arises from photons (as metastable phase vortices with $E_\gamma > T_0$) intrinsically losing energy very slowly over cosmological timescales, relaxing towards the background state.
  - Crucially, the rate of this energy loss is modulated by the local phase tension, T_{local}:
    - In denser regions like galaxies, T_{local} is higher (due to the concentration of matter vortices), so the gradient $E_\gamma - T_{local}$ is smaller, and photons lose energy *slower*.
    - In voids, $T_{local} \approx T_0$ (very low), the gradient $E_\gamma - T_{local}$ is larger, and photons lose energy *faster*.
  - This elegantly explains observed variations in the Hubble parameter or "accelerated expansion" as an artifact of the photon's path through varying T_{local} environments, rather than actual acceleration of spatial expansion. Photons traversing more void-rich paths would exhibit greater redshift for a given distance.

9.3 Formation of Large-Scale Structure (LSS):

- **Mechanism:** The "cosmic web" of galaxies, clusters, filaments, and voids is proposed to form from primordial fluctuations in the phase tension (δT_0) or phase density within an initially nearly uniform phase background.
- **Phase Collapse:** Regions with initially higher phase tension or density ($\delta T_0 > 0$ or $\delta \rho_m > 0$) act as gravitational attractors within the GPT framework (analogous to Jeans instability). These regions draw in

and condense surrounding phase energy and pre-existing less-dense vortices, eventually forming the nodes (clusters) and filaments of the cosmic web. Voids, conversely, are regions where the phase background remains relatively rarefied or where phase tension has been "drained" into surrounding structures.
- **No Dark Matter Required:** The formation and stability of these structures are explained by phase gravity (including the dynamic κ or a_0 effect arising from background properties discussed in Section 6.3) acting on ordinary (baryonic) matter and the self-interaction of the phase field itself. GPT does not require the existence of non-baryonic dark matter particles to explain galactic halos or the overall mass budget of clusters.

9.4 Interpretation of the Cosmic Microwave Background (CMBR) and Baryonic Acoustic Oscillations (BAO):

- **CMBR:**
  - In GPT, the CMBR is not viewed as relic radiation from a hot "fireball" Big Bang in the standard sense. Instead, it's interpreted as the thermal equilibrium radiation of the phase background itself. This radiation consists of the uncoordinated, subcritical phase fluctuations ($\delta\phi$) discussed in Section 2.1 and Section 8.2.
  - The observed temperature of the CMBR (≈ 2.725 K) reflects the average energy density or "temperature" of these background phase fluctuations at the epoch when the Universe became "transparent" to these long-wavelength phase waves, or when primordial photons had lost enough energy via phase drift/fatigue to merge with this background thermal bath.
  - **Anisotropies ($\Delta T/T$):** The small temperature anisotropies in the CMBR are direct imprints of the primordial spatial fluctuations in the phase background tension (δT_0) or density. These variations in the background influenced the energy of the last scattered/emitted phase waves. The angular power spectrum of these anisotropies would reflect the statistical properties of these initial phase field irregularities. GPT predicts potential deviations from ΛCDM, especially at large angular scales, and possible non-Gaussian signatures.
- **BAO:**
  - The characteristic scale observed in the distribution of galaxies (BAO peak) is interpreted as the imprint of phase density waves that propagated through the early Universe's "phase plasma" (a dense state of interacting phase vortices and background fluctuations).
  - The radius of the "phase sound horizon" ($r_{s,phase}$) at the epoch of "decoupling" (when these waves "froze out") is determined by the propagation speed of these phase density waves (which depends on the phase pressure and effective phase density of the early Universe) and the history of the phase scale factor $a_{phase}(t)$. This scale can differ slightly from the standard sound horizon, potentially leading to observable differences in the BAO feature.

9.5 Other Cosmological Considerations:

- **Hypothesis of Hidden Early Metallicity:** GPT allows for the possibility that dense cores of heavy elements could have formed very early in cosmic history within regions of exceptionally strong primordial phase collapse. These "bare" nuclei might not have initially captured extensive electron clouds and thus would have been "dark" to standard spectroscopic metallicity surveys of very distant/early objects, potentially explaining observations of "surprisingly" metal-rich objects at high redshifts.
- **Constancy of Fundamental Constants:** The primary formulation of GPT assumes that fundamental constants like G_{phase} (related to G), K_{phase} (related to $\hbar$), and c are intrinsic properties of the stable phase background and thus do not change over cosmological time. Observed cosmological evolution is attributed to changes in the *state* of the background (e.g., $T_0(t)$ or $\kappa(t)$ due to dynamic background response), not changes in the fundamental laws themselves. (An earlier, now less favored, variant considered the possibility of slowly evolving constants tied to $a_{phase}(t)$).

In essence, phase cosmology describes an evolving Universe governed by the internal dynamics of a fundamental phase field, offering alternative explanations for key observational data without invoking concepts like the metric expansion of space, particle dark matter, or a cosmological constant driving accelerated expansion.