Medium-Mapped Harmonic System

An Acoustics-Based Parameter Space for Cross-Medium Harmonics, Wavelength Composition, and Generative Expansion

Abstract

The *Medium-Mapped Harmonic System* is a physics-anchored musical framework that treats **acoustic propagation medium** as a first-class compositional parameter. Instead of defining pitch relationships solely within a single abstract tuning space (e.g., a fixed temperament or ratio system), this approach maps harmonic structures through the fundamental physical relationship between **frequency (f), wavelength (λ), and propagation velocity (v)**, using the identity **λ = v / f** (and equivalently **f = v / λ**). Because **v** varies substantially across physical media, the same nominal frequency implies different wavelengths in air, helium, hydrogen, or water—creating distinct, measurable "harmonic geometries" that can be explored as musical structure.

The framework begins with a chosen tonal reference (a fundamental) and derives **harmonic and subharmonic ladders** as stable numerical families. These ladders may be expressed simultaneously as frequency sets and as angular frequency (radians/sec), allowing the system to interface naturally with both musical and signal-processing descriptions. The distinguishing move is then to project these harmonic families into **medium-specific wavelength spaces** using known propagation velocities. For example, at comparable conditions (e.g., ~20°C), air (~343 m/s), helium (~1,007 m/s), hydrogen (~1,270 m/s), and water (~1,481 m/s) yield materially different wavelength values for the same harmonic index. This establishes a multi-medium, multi-representation harmonic atlas: each tone can be treated as a point in a coordinated space of *(harmonic index, frequency, wavelength, medium)*.

A second operational mode reverses the mapping: by selecting a **wavelength target** (e.g., a physical length scale), the system derives the corresponding **frequency in each medium** via **f = v / λ**, producing a cross-medium frequency set from a single spatial parameter. This enables a compositional workflow in which musical material can be generated from physical constraints (length, scale, propagation context) rather than from historical harmonic convention. In this sense, "infinite" refers not to metaphysical claims, but to a practically unbounded **parameter space**: continuously variable wavelength targets, multiple media, and multiple ladder depths yield vast combinatorial families while remaining grounded in stable physical identities.

The Medium-Mapped Harmonic System is intended as an expansion branch alongside tonal and compositional gravity frameworks. It does not replace existing tuning theory; rather, it offers a rigorous method for exploring how musical identity can be constructed from **propagation physics**. Potential applications include experimental composition, acoustics-informed instrument design, new control spaces for synthesis and physical modeling, and generative music systems where physical parameterization can serve as an interpretable constraint layer. By binding musical structure to measurable propagation relationships, the system provides a disciplined way to explore novel harmonic terrains while retaining numerical stability and cross-representation coherence.