Informational Curvature and Semantic Gravitation

This section develops the analogy between informational density in semantic systems and gravitational curvature in physical systems. In the same way that mass distorts spacetime in general relativity, we propose that highly dense semantic content distorts the structure of the surrounding belief graph or knowledge manifold.

1. Semantic Weight and Information Density

Each node $v \in V$ in a semantic graph carries a weight $w(v)$ that reflects its informational mass. This may be measured as:

- Compression depth (Kolmogorov complexity)
- Connectivity strength (degree, centrality)
- Provenance density (number of derivations, validation confidence)

This defines a field of semantic mass distribution over the graph.

2. Edge Tension and Curvature

Given two connected nodes v_i and v_j, we define the semantic tension across the edge as:

$$\kappa_{ij} = |w(v_i) - w(v_j)|$$

High tension implies increased semantic distortion—a curvature in the field that resists or amplifies flow. This is analogous to geodesic deviation in curved spacetime.

3. Semantic Potential Field

We define the semantic potential at node v as:

$$\phi(v) = \sum_{u \in \mathrm{Nbr}(v)} \frac{w(u)}{d(u, v)}$$

This is the epistemic analog of gravitational potential. The gradient of this field defines a flow vector:

$$\vec{G}(v) = -\nabla \phi(v)$$

which we call the *semantic gravitation field*. Nodes with high local $\vec{G}$ exhibit strong inferential attraction or distortion.

4. Semantic Gravitation Constant

We introduce a new constant G_{sem} that governs the strength of semantic curvature. It appears in the force law:

$$F = G_{\mathrm{sem}} \cdot \frac{w(v_i) \cdot w(v_j)}{d(v_i, v_j)^2}$$

This describes how informationally heavy nodes bend the space of interpretive possibility around them—biasing nearby inferences, belief update paths, and observation interpretations.

5. Relaxation and Drift Zones

Over time, semantic strain diffuses through the graph. The resulting dynamic is governed by:

$$\frac{\partial \rho}{\partial t} = \nabla \cdot (\vec{G}(v) \cdot \rho)$$

where $\rho(v)$ is a local belief or observation density. The diffusion process models how an insight ripples outward, or how a contradiction causes widespread structural shift.

6. Implications and Observables

- Semantic attractors and false beliefs may arise from excessive local mass.
- Observation chains preferentially follow geodesics in $\vec{G}(v)$.
- Drift correction and stable learning must account for $\phi(v)$ and its gradients.

Future work may define a full Riemannian structure on the belief manifold, using $w(v)$ as curvature source and geodesics as optimal inference paths.