Fundamental Interaction Language

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Chapter 1

Foundations and Semantic Constants

1.1 The Information–Observation–Language (I–O–L) Triad

Modern knowledge systems reveal a recurring motif: comprehension requires only the *differences* between two bodies of knowledge, not their entirety. We formalise this with the **Information–Observation–Language triad**

$$(\mathcal{I}, \mathcal{O}, \mathcal{L}) = (\mathcal{I}, \mathcal{O}, \mathcal{L}), \tag{1.1}$$

where $\mathcal{I}$ denotes possible information states, $\mathcal{O}$ the set of admissible observations, and $\mathcal{L}$ the symbolic language capable of encoding both. Minimal "bridges" between domains are implemented by Local Language Constructors (LLCs), treated in Chapter **??**.

1.2 Foundational Postulates

Postulate F1 (Semantic locality). Any act of communication factors through a finite sub-language $B \subseteq \mathcal{L}$ such that $E \otimes B \cong \mathcal{L}$, with E the receiver's existing language fragment.

Postulate F2 (Minimal bridges). Among all such B, natural communication selects one that minimises $|B|$.

Postulate F3 (Hierarchical union). Languages compose by hierarchical union and the semantic density ρ is non-decreasing under this union.

1.3 Semantic Constants

We introduce two universal constants:

c_s the *semantic light-speed*, bounding information propagation in a knowledge graph:

$$d_G(v_1, v_2) \;\leq\; c_s\,\Delta t. \tag{1.2}$$

$\hbar_s$ the *semantic Planck constant*, appearing in an uncertainty relation between discovery and invention operators:

$$\Delta D\,\Delta I \;\geq\; 12\hbar_s. \tag{1.3}$$

Convenient units set $c_s = \hbar_s = 1$; deviations measure complexity.

1.4 Road-map

This chapter establishes notation for the remainder of the book. Chapter **??** develops the geometric view (c_s as cone slope), Chapter **??** derives global limits from Eq. eq:sem-uncertainty, Chapter **??** treats drift and masks, and Chapter **??** links the constants to physical information bounds.

Take-away. The triad $(\mathcal{I}, \mathcal{O}, \mathcal{L})$ and constants $(c_s, \hbar_s)$ provide an irreducible substrate on which all higher FIL structures are built.

Chapter 2

Semantic Geometry

2.1 Semantic Light-Cones

In a knowledge graph $G = (V, E)$ we define the *semantic distance* $d_G(v_1, v_2)$ as the minimal edge-weighted path length between two concept vertices. Postulate F1 implies that information flow is bounded by the constant c_s introduced in Chapter **??**:

$$d_G(v_1, v_2) \;\leq\; c_s \, \Delta t. \tag{2.1}$$

Points satisfying equality trace **semantic light-cones**. They encode the frontier beyond which two agents cannot reach mutual comprehension within Δt.

Propagation kernel. Let $K_t(v)$ denote the reachable set from v in time t. A discrete propagator is $P_t = 1_{d_G \leq c_s t}$.

2.2 Informational Curvature

Light-cone slope alone does not capture *semantic gravitation*—the tendency of dense subgraphs to attract interpretive trajectories. We introduce an *informational curvature tensor* $\mathcal{K}$ via the deviation of geodesics in G:

$$\delta^2 d_G = -\mathcal{K}(\gamma, \dot{\gamma}) \, d\sigma^2. \tag{2.2}$$

Positive curvature corresponds to semantic "mass" and appears near high mutual-information clusters. See [**?**](§2) for the full derivation.

Example – category junction

Two dense languages L_1, L_2 joined by a minimal LLC bridge B create negative curvature in the bridge (saddle) and positive curvature inside each language core.

2.3 Computational Spacetime Correspondence

Mapping Eq. eq:semantic-cone onto a Turing tape with physical delays τ, we recover the computational light-speed bound $c_s \approx 1/\tau$ [?]. Informational curvature then corresponds to non-uniform memory access latencies—regions of high semantic mass behave as RAM "black holes".

2.4 Meta-Law and Quantisation

FL_Field Meta-Law postulates a universal action principle in information space. Quantising small oscillations of d_G about a ground state yields a discrete spectrum analogous to normal modes in Riemannian geometry. This motivates the uncertainty relation derived in Eq. (**??**).

Take-away. The geometry of semantic light-cones and informational curvature generalises relativistic causality to knowledge systems, setting the stage for global bounds (Chapter **??**) and dynamical drift analysis (Chapter **??**).

Chapter 3

Informational Bounds

3.1 Bekenstein-like Entropy Limit for Language

The classical Bekenstein bound [?] constrains the maximum entropy S of physical matter in a region of radius R and energy E by $S \leq 2\pi kER/\hbar c$. In the FIL setting, tokens carry informational mass and the analogue becomes

$$H(\mathcal{L}) \;\leq\; 2\pi\, k_s\, E_{\mathcal{L}}\, R_{\mathcal{L}} \,/\, \hbar_s, \tag{3.1}$$

where $E_{\mathcal{L}}$ is the cumulative energetic cost of storing the language fragment and $R_{\mathcal{L}}$ its semantic diameter.

Interpretation. If H exceeds this limit, further compression (via LLC bridges) or hierarchical segmentation is required.

3.2 Finite Knowledge Bounds

Let $G = (V, E)$ be a directed knowledge graph with path entropy H_P and symbol complexity C_s. finiteknowledgebounds2025 derive upper and lower compression bounds

$$\frac{|V|}{\log C_s} \;\leq\; H_P \;\leq\; |E|\, \log C_s. \tag{3.2}$$

We adopt the lower bound as the *finite knowledge bound* (FKB) for any segment.

3.2.1 Prime-Encoding Lower Bound

Prime-encoding of edge labels achieves the lower bound asymptotically; see Appendix ??.

3.2.2 Voronoi Capacity Upper Bound

Semantic Voronoi cells give a geometric ceiling; we revisit this in Chapter **??** when studying drift fields.

3.3 Acceleration Constraint

accelleration2025 show that rapid semantic updates imply an *acceleration cost*

$$a_{\mathcal{L}} \equiv \frac{d^2H}{dt^2} \le c_s^2/\ell_{\min}, \tag{3.3}$$

with $\ell_{\min}$ the minimum edge length. This links light-cone slope (c_s) to second-order dynamics.

3.4 Big Bang as Information Phase Transition

The cosmological Big Bang is recast as a phase transition where $H \to 0$ while $dH/dt \to \infty$. Under FKB this corresponds to the creation of the minimal language fragment required for any subsequent evolution.

3.5 Road-map

Informational limits set the stage for Chapter **??**, where drift and masks operate within these bounds, and Chapter **??**, which ties them to particle-level information exchange.