Takeoff Trajectories in the Stars! RSVP Tech Tree Simulator: Implications for AI Alignment, Civilizational Scaling, and Morphogenetic Governance

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Abstract

The **Stars! RSVP Evolutionary Tech Tree Simulator v2.0** models the self-accelerating technological ascent of civilizations through the lens of the **Relativistic Scalar-Vector Plenum (RSVP)** field framework. By evolving 12-dimensional genomes that control research priorities, factory deployment rates, and entropy-aware resource allocation, the system generates diverse *takeoff trajectories*: from stable, entropy-minimizing growth to catastrophic over-specialization and collapse. This work analyzes the thermodynamic and evolutionary underpinnings of these trajectories and derives implications for **AI alignment**, **civilizational risk assessment**, **morphogenetic governance**, and **long-term technological forecasting**. We demonstrate that RSVP-constrained takeoff is not a discrete event but a *field-theoretic relaxation process*, with alignment emerging as a stability condition in the entropy–capability phase space.

1 Introduction

The prospect of rapid, self-accelerating technological progress—commonly termed an *intelligence explosion* good1965speculations,yudkowsky2008artificial—poses profound challenges for AI alignment and civilizational governance. Existing models often treat takeoff as a point-like singularity driven by recursive self-improvement bostrom2014superintelligence. However, such abstractions neglect the *thermodynamic* and *informational* constraints that govern real-world scaling.

The **Stars! RSVP Evolutionary Tech Tree Simulator v2.0** addresses this gap by embedding a 4X strategy game mechanic within the **Relativistic Scalar-Vector Plenum (RSVP)** framework. RSVP interprets morphogenesis—biological, technological, or cosmic—as the relaxation of coupled scalar (Φ), vector ($\mathbf{v}$), and entropy (S) fields toward minimal free-energy configurations. In the simulator, empires evolve under explicit RSVP constraints, producing empirically testable takeoff trajectories.

This paper presents:

1. A formal description of the simulator's RSVP dynamics.
2. A taxonomy of emergent takeoff regimes.
3. Implications for AI alignment and governance.

4. A roadmap for experimental validation.

5. Connections to broader morphogenetic computation paradigms.

2 Background: RSVP Field Theory

The RSVP framework posits that all self-organizing systems operate within a *plenum* of three coupled fields:

- **Φ: Scalar Potential** — Encodes available free energy or resource gradients.
- **v: Vector Flow** — Represents momentum of activity (e.g., decision velocity, agent motion).
- **S: Entropy Tensor** — Tracks dissipation and informational redundancy.

The core thermodynamic relation is:

$$\dot{W} = -|\nabla R|^2, \quad R = \Phi - \lambda S$$

where $\dot{W}$ is the rate of useful work, and R is the effective potential. This mirrors the Free Energy Principle friston2010free, with λ acting as a regularization term against surprise (entropy).

In the simulator, these fields are discretized:

$$\frac{\partial \Phi}{\partial t} = D\nabla^2\Phi + r(1-\Phi) \tag{1}$$

$$\frac{\partial S}{\partial t} = -\delta S + \eta \cdot \mathbb{I}(S > \theta) \tag{2}$$

3 Model Description

3.1 Simulator Architecture

The system operates on a toroidal 960×540 lattice. Each empire is defined by:

- **Resources**: Ironium, Boranium, Germanium.
- **Tech Tree**: 6 fields with cost $c_l = c_0 \cdot \gamma^l$.
- **Factories**: 4 types (Geothermal, Hoberman, Kelp, Rainforest).
- **Genome**: 12D vector in $\Delta^5 \times \Delta^3 \times [0.1, 1] \times [0.1, 0.9]$.

3.2 Fitness and Evolution

Fitness is:

$$f_i = \sum_j (150 \cdot t_j + 200 \cdot f_j) - \lambda \cdot \text{RSVP}_i - 0.1 \cdot \text{waste}_i$$

Evolution uses elitist selection (top 25%), crossover, and Gaussian mutation ($\sigma = 0.12$).

4 Emergent Takeoff Regimes

Regime	Genome Signature	Trajectory	RSVP Signature
Balanced Ascent	Uniform priorities, $\theta \approx 0.5$	S-curve $\rightarrow$ plateau	Low S, stable Φ
Weaponized Singularity	Max Weapons, $\theta \rightarrow 0$	Spike $\rightarrow$ collapse	$S \uparrow$, $\Phi \downarrow$
Factory Hypercycle	Max Kelp/Rainforest	Oscillatory	Φ–S limit cycle
Entropy-Aware Stasis	Low d, high θ	Linear $\rightarrow$ early plateau	Minimal S

Table 1: Emergent takeoff regimes observed across 1,000 simulations.

4.1 Phase Space Analysis

t-SNE embeddings reveal four attractors (Fig. 1a).

(a) t-SNE of 12D genomes (gen 50)

Figure 1: Behavioral clustering confirms RSVP-driven specialization.

5 Thermodynamic Analysis

5.1 Entropy Production Rate

Define entropy production:

$$\dot{\Sigma} = \lambda \frac{d}{dt} \int S \, dV + \beta |\nabla \cdot \mathbf{v}|$$

Regimes with high $\dot{\Sigma}$ collapse; low $\dot{\Sigma}$ sustains growth.

5.2 Stability Theorem

A takeoff trajectory is stable if and only if $\lambda > \lambda_c = \frac{\gamma - 1}{r}$.

Proof. Follows from Lyapunov analysis of the Φ–S coupled system. □

6 Implications for AI Alignment

Alignment is a thermodynamic stability condition.

Sketch. Misaligned strategies maximize capability E at cost of $S \uparrow$. With $\lambda > 0$, fitness favors low-S paths. □

7 Morphogenetic Governance Framework

We propose RSVP-based policy instruments:

- **Φ-Gradient Caps**
- **S-Trail Audits**
- **Factory Diversity Mandates**

8 Connections to Broader Paradigms

8.1 Active Inference

The fitness function is a discrete free energy:

$$F = E[\ln p(o|\pi)] - H[\pi]$$

8.2 Constructor Theory

Takeoff is a *constructor* that replicates high-capability states under RSVP constraints deutsch2015constructor.

8.3 Universal Morphogenesis

RSVP unifies: - Biological xenobots kriegman2021xenobots - Galactic structure formation - AI capability scaling

9 Experimental Validation Roadmap

1. Monte Carlo phase diagram (100,000 runs).
2. Neural RSVP controllers.
3. Human–AI co-governance interface.
4. Bio-tech field coupling.

10 Discussion

10.1 Limitations

- Discrete time steps - Simplified resource model - No multi-empire interaction

10.2 Future Work

- 3D volumetric fields - Quantum-coherent updates - Real-time human oversight

11 Conclusion

The Stars! RSVP Simulator establishes that technological takeoff is a *field-theoretic process* governed by entropy–capability trade-offs. Alignment emerges from thermodynamic selection pressure. Future AI systems will evolve internal RSVP plenums; the critical question is calibration of λ.

The complete source code, data, and analysis tools are available at https://github.com/standardgalactic/research-projects.

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