Lagrange Points Are the Next Frontier of Superintelligence

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Abstract

The exponential scaling of Artificial General Intelligence (AGI) is rapidly approaching the thermodynamic and power-density limits of terrestrial infrastructure. This paper proposes a multi-tiered off-world supercomputing architecture: the *Lagrangian Compute Hierarchy*. We argue for a phased migration, beginning with the **Earth-Moon Trojan points** (L_4/L_5) to support low-latency inference and edge-learning, followed by the **Sun-Earth Trojan points** (L_4/L_5) for massive-scale foundation model training. By leveraging the Coriolis-stabilized potential wells of the L_4/L_5 points, we circumvent the station-keeping costs inherent to unstable collinear points (L_1, L_2). This architecture provides a necessary condition for the sustainable expansion of superintelligence beyond the Earth's planetary heat-sink capacity.

Project Page: https://github.com/yifanzhang-pro/lagrange-superintelligence

1 Introduction

Empirical scaling laws in deep learning demonstrate a consistent power-law relationship between compute budget and model proficiency. As we approach the yottaflop regime, terrestrial data centers face existential constraints: localized power grid saturation and the atmospheric thermal dissipation limit.

To transcend these limits, we propose the "Orbital Cloud." However, orbital selection is non-trivial. Low Earth Orbit (LEO) is untenable due to atmospheric drag and debris risks, while collinear Lagrange points (L_1, L_2) function as unstable saddle points requiring continuous propellant consumption. Instead, we advocate for the Trojan points (L_4/L_5), which offer long-term structural stability via effective potential maxima.

This paper outlines a tiered roadmap: the *Cislunar Compute Network* for rapid-response inference, and the *Heliocentric Swarm* for asynchronous, high-throughput training.

2 Background: The Three-Body Advantage

In the Circular Restricted Three-Body Problem (CR3BP), there exist five equilibrium points. For the purpose of permanent high-mass infrastructure, these points bifurcate into two stability classes:

- **Unstable Collinear Points (L_1, L_2, L_3):** These are saddle points. Maintaining a cluster here requires active station-keeping; any perturbation leads to exponential divergence from the equilibrium. This imposes a "propellant tax" that scales with infrastructure mass, making them unsuitable for multi-ton compute clusters.
- **Stable Trojan Points (L_4, L_5):** Located at the vertices of equilateral triangles in the orbital plane, these points are dynamically stable if the mass ratio $\mu < 0.0385$. Objects here undergo stable libration, allowing for the construction of massive, modular compute swarms with minimal active control.

3 Phase I: The Earth-Moon Cislunar Tier

The Earth-Moon L_4 and L_5 points represent the optimal staging ground for the first generation of orbital AGI hardware.

3.1 Latency and Connectivity

The Earth-Moon system provides a one-way light time (OWLT) of ≈ 1.28 seconds. High-bandwidth optical (laser) cross-links allow this tier to function as a low-latency extension of terrestrial networks:

- **Inference Clusters:** Hosting large language models (LLMs) where human-perceptible latency is acceptable, preserving terrestrial energy for edge-computing.
- **Tele-robotic Maintenance:** Proximity enables near-real-time robotic servicing and modular expansion using Earth-based operators.

3.2 Orbital Dynamics

The Trojan points offer "passive safety." While an asset at L_1 would drift away within weeks of a guidance failure, a cluster at L_4/L_5 remains trapped within the potential well, executing stable libration orbits. This protects capital-intensive hardware from permanent loss during power or propulsion failures.

Algorithm 1 Cislunar Station Keeping (Earth-Moon)

Require: State vector $\mathbf{x}$, Solar Perturbation $\vec{F}_{sun}$
Ensure: Control $\vec{u}$ maintains libration orbit

$\vec{r}_{moon} \leftarrow \text{Ephemeris}(t)$
$\vec{F}_{tidal} \leftarrow \nabla U_{moon}(\vec{r}) + \nabla U_{earth}(\vec{r})$
if drift $> \epsilon_{threshold}$ **then**
    $\vec{u} \leftarrow -K(\vec{F}_{tidal} + \vec{F}_{sun})$ ▷ Counter solar perturbation
else
    $\vec{u} \leftarrow 0$
end if

4 Phase II: The Sun-Earth Heliocentric Tier

As computational demand moves from inference to foundation training, the architecture migrates to the Sun-Earth L_4/L_5 points.

4.1 The Energy-Latency Tradeoff

At a distance of 1 AU, the $\approx$ 8-minute OWLT necessitates a transition to strictly **asynchronous workloads**:

- **Asynchronous Foundation Training:** Global gradient updates are robust to minute-scale delays, making these points ideal for massive-scale pre-training.
- **Propellant-Free Longevity:** By utilizing solar radiation pressure for momentum management, these clusters can achieve operational lifespans exceeding 50 years.

4.2 Thermodynamic Superiority

At Sun-Earth L_4, the station is permanently outside the Earth's shadow.

$$P_{in} = \eta \cdot A_{array} \cdot S_0 \tag{4.1}$$

With a solar constant $S_0 \approx 1361\,\mathrm{W/m^2}$ and a 100% duty cycle (zero eclipse), power availability is maximized.

5 Deep Space Thermal Management

Heat rejection in a vacuum is governed by the Stefan-Boltzmann law:

$$\dot{Q}_{out} = \epsilon \sigma A_{rad}(T^4_{radiator} - T^4_{background}) \tag{5.1}$$

By employing Sun-shielded multi-layer insulation (MLI) and V-groove radiators, we can reach the cryogenic temperatures necessary for superconducting compute fabrics, drastically reducing internal resistive losses.

6 Conclusion

The migration of superintelligence to Lagrangian points is an inevitable consequence of the thermodynamic limits of Earth. This tiered architecture, utilizing the Earth-Moon system for inference and the Sun-Earth system for training, provides a scalable, stable, and energetically abundant roadmap for the future of AGI.