Formation of Second-Generation Exoplanets in Resonant Fallback Disks Around Black Holes

Author : Alaa Salah Afifi

Affilation : Kepler space University

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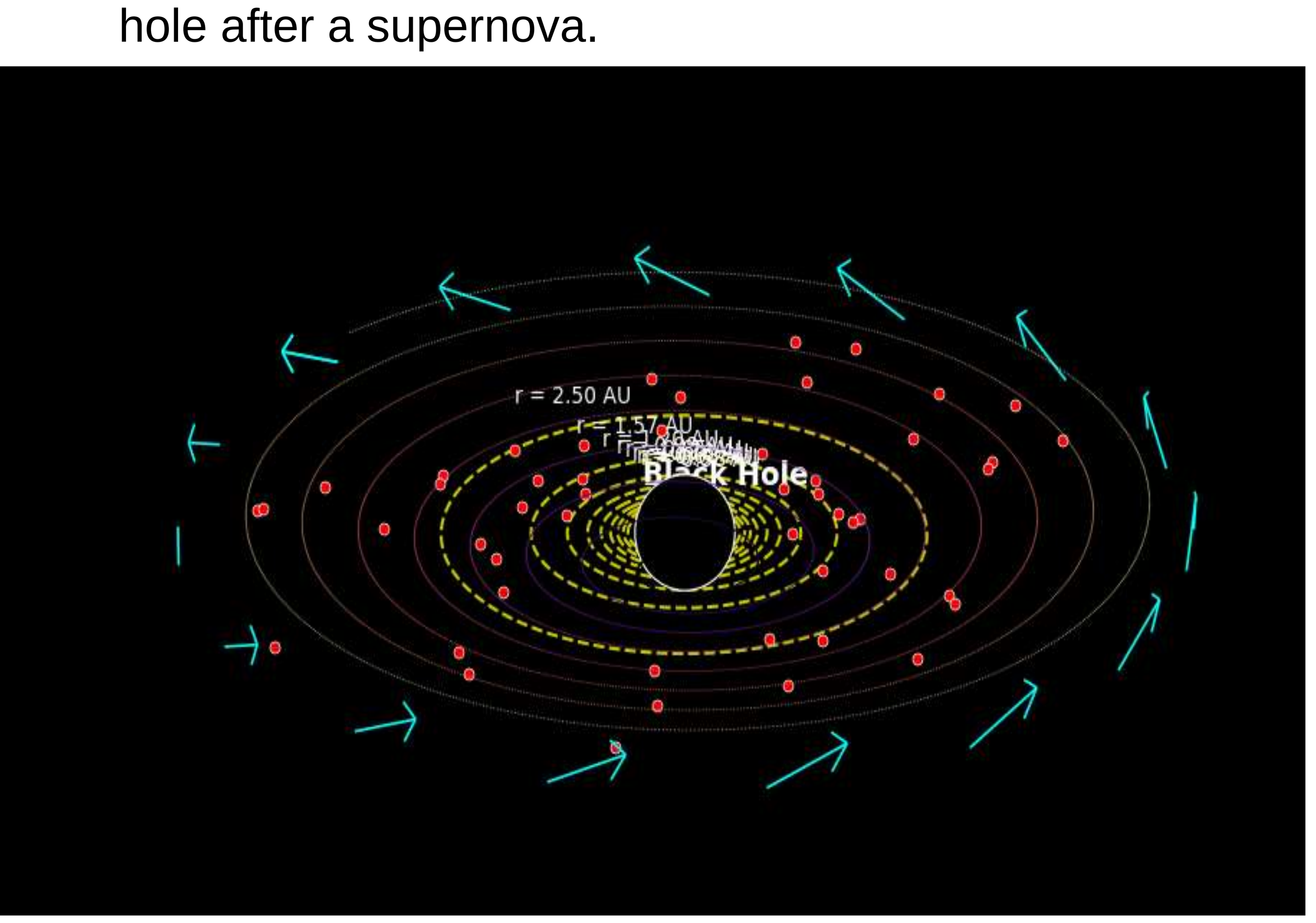
Abstract

While formation of planets is generally associated with young stellar systems, there are recent theoretical advances that suggest an intriguing alternative: second-generation exoplanets developing in fallback disks around black holes. Such disks, consisting of matter that fails to escape during a supernova explosion, can consist of resonant regions where matter condenses and gravitational instabilities cause planetary objects to form. This research mimics the physical environment of around such disks, testing their stability using the Toomre Q parameter, finding resonance zones, and simulating the formation of planetesimals under extreme relativistic conditions. Our simulations indicate that such a system is not only theoretically feasible but may already be detectable with current telescopes like JWST and ALMA.

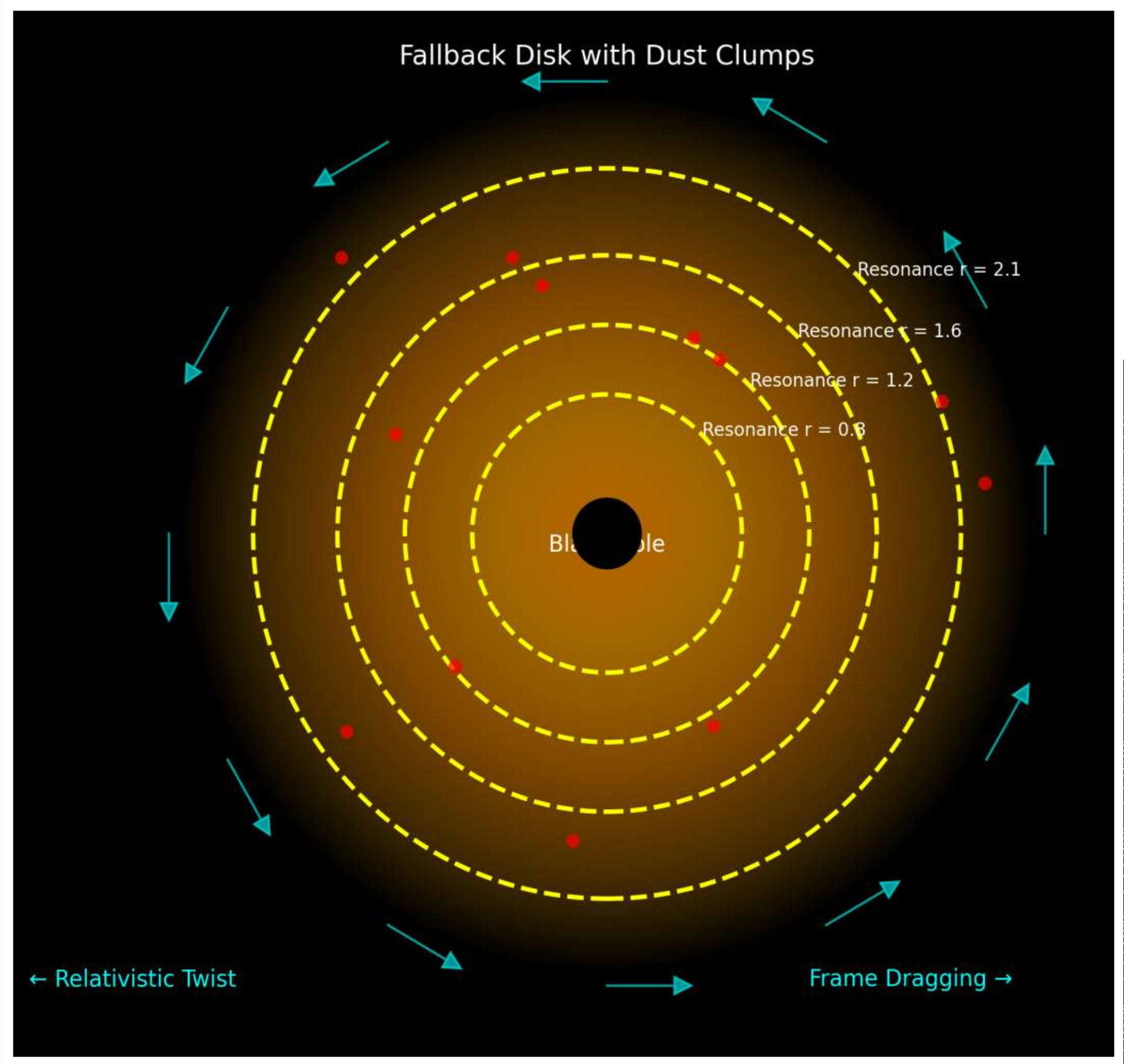
Introduction

What Are Second-Generation Planets?
Most exoplanets are born in protoplanetary disks around stars, but this study examines whether planets can also be born in fallback disks — matter discs that fall back upon a new-born black hole after a supernova.



Why This Matters
Potentially explains pulsar planets (e.g., PSR B1257+12)
Shakes our assumptions about habitability zones
Expands SETI potential to post-supernova habitats

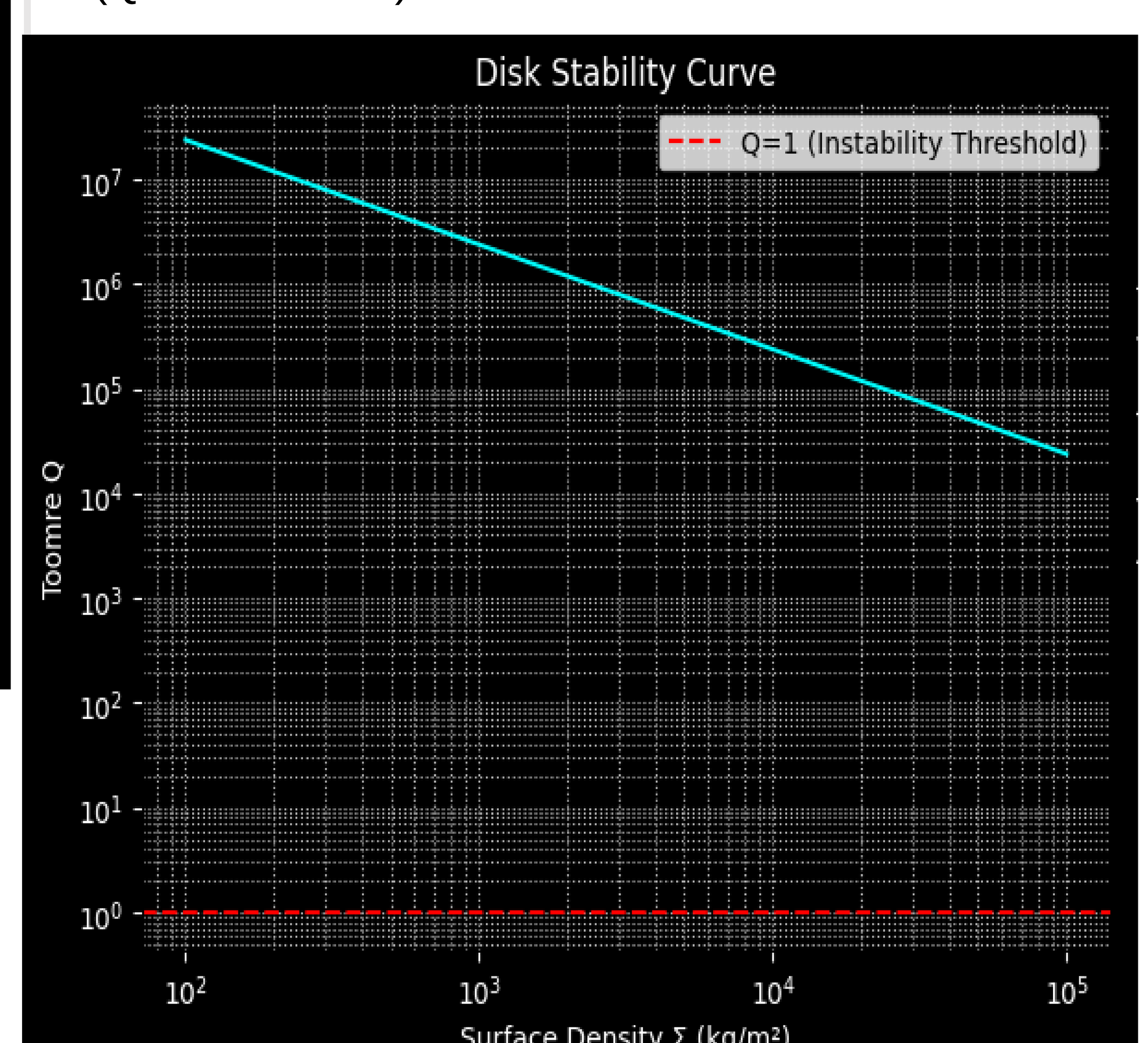
To model and simulate fallback disks and find where gravity instabilities, resonance regions, and relativistic effects can allow for planet formation.



Methodology

We modeled fallback disks from stellar collapse and assessed their ability to form second-generation exoplanets. Disk fragmentation was analyzed using the **Toomre Q criterion**: $Q = \frac{c_s \kappa}{\pi G \Sigma}$

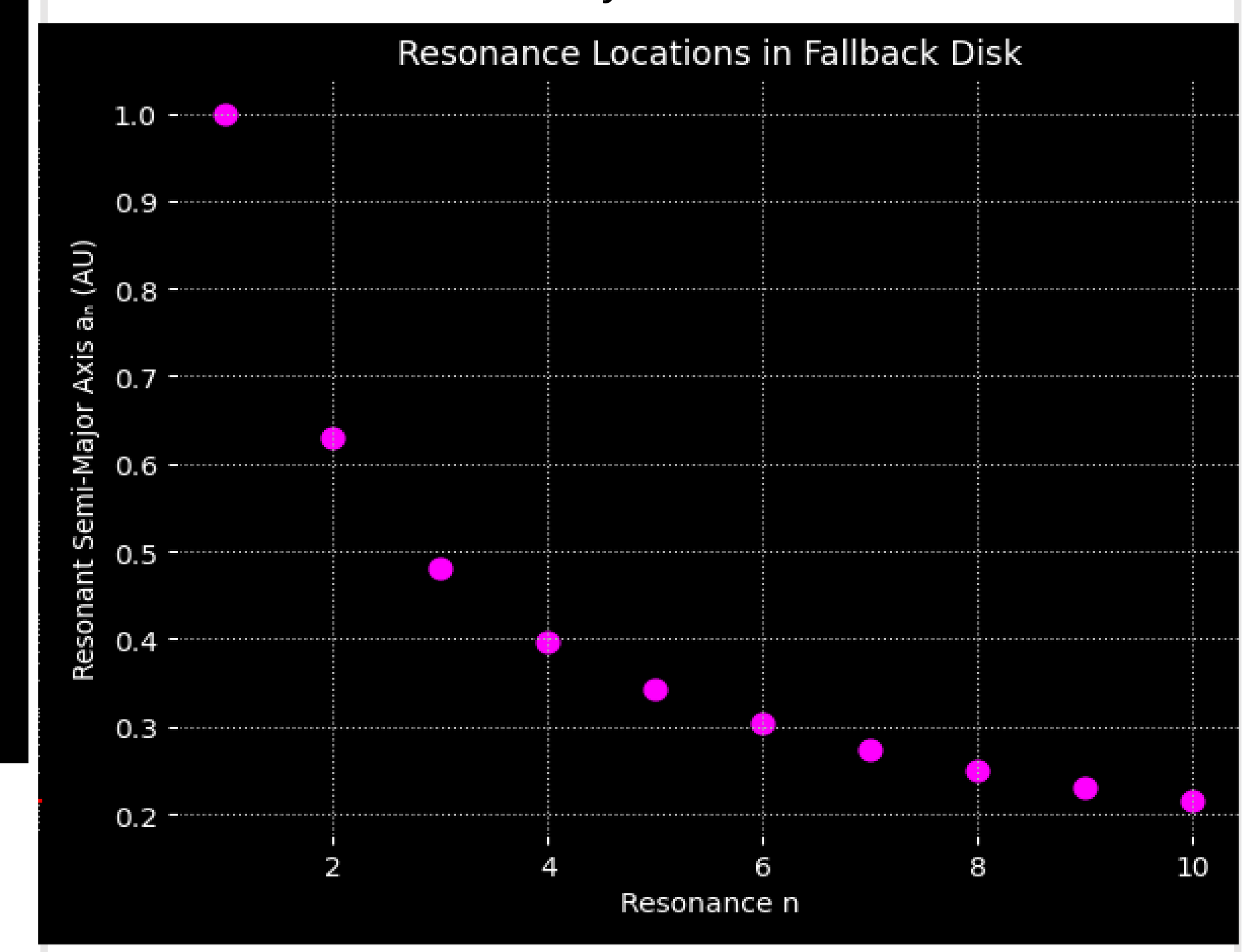
(Q<1⇒unstable)



Resonant zones were identified using:

$$\frac{n}{m} = \frac{\Omega - \kappa}{\Omega}$$

where dust traps enhance planetesimal formation.
Cooling conditions were applied via:
tcool·**Ω<βcrit≈3** A simplified orbital simulation visualized spiral inflow and ring formation.
Observational markers include **IR excess, disk warping**, and **X-ray polarization**. PSR B1257+12 was used as a reference system.



Results/Data Analysis

Toomre Q < 1 regions are favorable for the formation of planetesimals

Resonant rings pile up dust, triggering collapse

Disks show second-generation planet zones

Observable indications are:
• IR excess
• Disk warping
• X-ray polarization patterns (IXPE)

Radial resonance regions that capture gas and dust

Transfer of angular momentum via magnetic and thermal effects

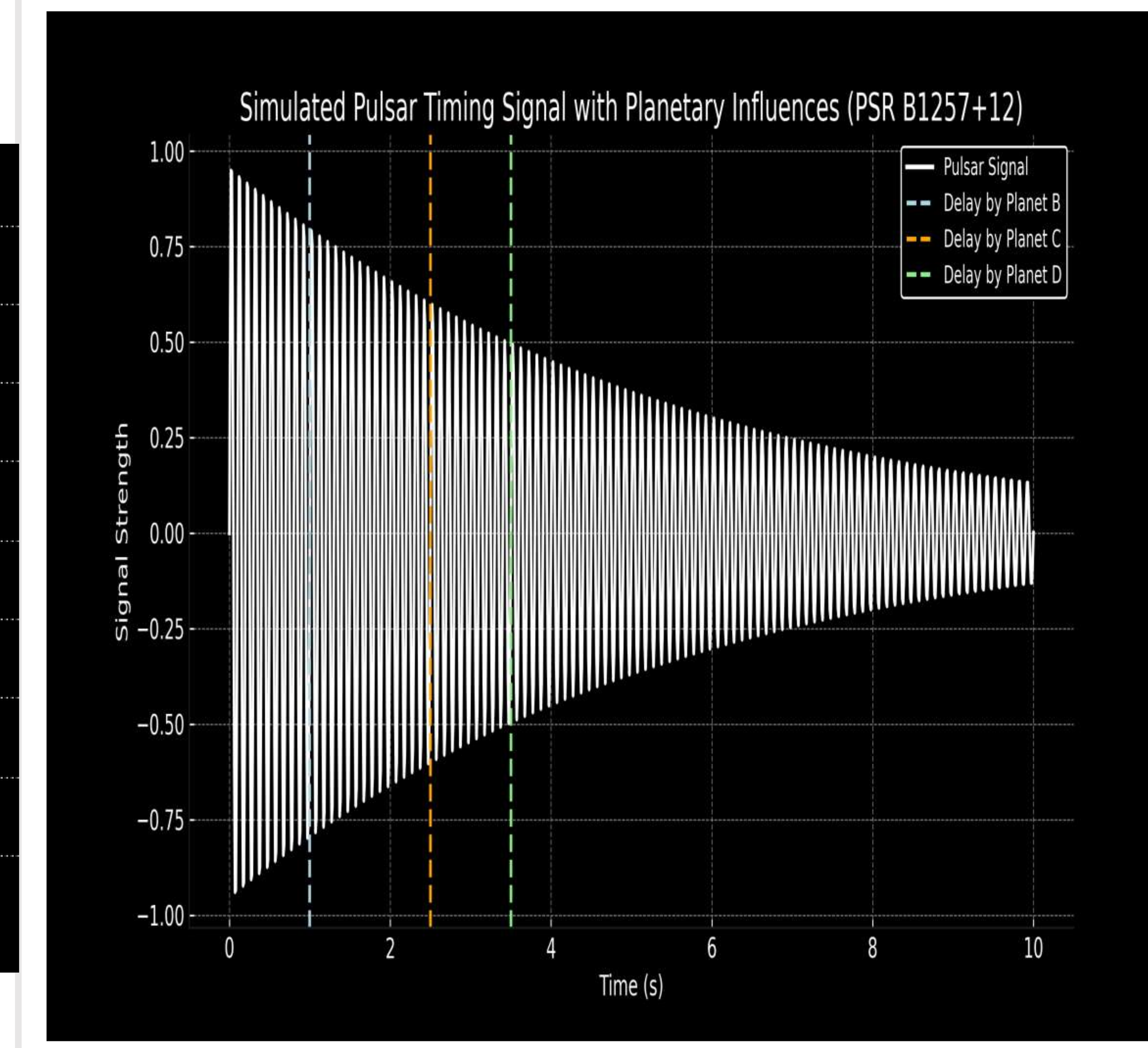
Frame dragging effect in Kerr black holes

Observational signatures via simulations (IR, ALMA, JWST)

Conclusion

Fallback disks can be planet factories and after cosmic death, too. This essay theorizes life-bearing worlds could have been born in places we never would have thought.

Sagan-Inspired Insight "Even in their deaths, stars seed life again. We are star stuff and so might new worlds created from black holes be.".



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