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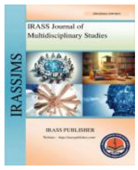

Kepler-56: A Case Study of Planetary Cannibalism around an Evolved Star

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Abstract: The fate of close-in planets orbiting stars evolving off the main sequence is governed by the rapid expansion of the stellar envelope and enhanced tidal dis-sipation. Kepler-56, a red-giant star hosting multiple planets on misaligned orbits, provides a rare opportunity to examine this process in an observed sys-tem. In this work, we investigate the tidal evolution of the inner planets in Kepler-56 and demonstrate that their present orbital configuration places them in a regime of runaway orbital decay as the stellar radius increases along the red-giant branch. We show that tidal torques acting within the deep convec-tive envelope lead inevitably to planetary engulfment on astrophysically short timescales. The analysis further suggests that planetary engulfment can con-tribute to the anomalously rapid rotation of the stellar envelope and may play a role in the observed spin–orbit misalignment between the stellar core and envelope. Kepler-56 thus serves as a benchmark system for studying plane-tary cannibalism during post-main-sequence stellar evolution and highlights the broader implications of tidal interactions for the long-term survival of close- in exoplanets. The Kepler-56 system therefore provides a valuable observational laboratory for studying the late-stage dynamical evolution and eventual engulf-ment of planetary systems around evolved stars.

Keywords: *Planetary cannibalism; star–planet interactions; tidal evolution; red giant stars; exoplanet dynamics.*

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Introduction

The long-term evolution of planetary systems is governed not only by their initial formation conditions but also by the subsequent evolution of their host stars. While most exoplanetary systems are discovered around main-sequence stars, stellar evolution inevitably alters the dynamical environment in which planets reside. As stars evolve off the main sequence and expand into sub- giants and red giantsVillaverLivio2009, close-in planets experience dramatically enhanced tidal interactions, leading to orbital decay, mass loss, or complete en-gulfment by the stellar envelope. This process—often referred to as planetary cannibalism—represents a critical but still poorly constrained phase in the life cycle of planetary systems Zahn1977,LilloBox2014. Observational evidence for planetary engulfment has historically been indirect, inferred from the paucity of short-period planets around evolved stars, anomalous stellar rotation rates, or chemical peculiarities such as lithium enrichment. However, these signatures are often degenerate and model-dependent. Directly identifying systems in which engulfment is ongoing or imminent remains challenging, yet such systems are essential for testing tidal dissipation theories and for understanding the ultimate fate of compact planetary architecturesZahn1977. The Kepler-56 system stands out as one of the clearest known examples of planetary cannibalism in action. The host star is an evolved red giant with a substantial convective envelope, while two inner planets orbit at small semi-major axes well within the regime where stellar tides are expected to dominate orbital evolution. A third, more distant companion on a wider orbit further distinguishes the system dynamically. The combination of close-in planets, an expanded stellar radius, and a dynamically structured architecture makes Kepler-56 a natural laboratory for studying tidal decay and engulfment during post–main-sequence stellar evolutionLilloBox2014.

A key advantage of Kepler-56 is the availability of aster seismic constraints on the host star. These measurements provide precise estimates of stellar mass, radius, internal structure, and evolutionary state, thereby reducing uncertain-ties that often plague studies of evolved hosts. When combined with well-characterized planetary orbits, this allows the tidal evolution problem to be addressed quantitatively rather than statistically. In particular, the steep dependence of tidal dissipation on stellar radius implies that even modest stellar

expansion can trigger runaway orbital decay, potentially leading to rapid engulfment on timescales short compared to the red-giant lifetime. In this paper, we examine the Kepler-56 system as a representative case

of planetary cannibalism around an evolved star. "Planetary engulfment (often referred to as planetary cannibalism) during post–main-sequence stellar evolution has been extensively studied both theoretically and observationally (e.g. Villaver & Livio 2009VillaverLivio2009; Villaver et al. 2014Villaver2014; Mustill & Villaver 2012)MustillVillaver2012." We compile the observed stellar and planetary parameters, derive tidal decay equations appropriate for stars with deep convective envelopes, and assess the orbital evolution of the inner planets as the host ascends the red-giant branch. We also discuss the role of the outer companion in shaping the system's dynamical architecture and consider the broader implications for the survival of close-in planets around evolved stars.

System Parameters

Overview of the system

The Kepler-56 system consists of an evolved red-giant host star orbited by two close-in planets (Kepler-56 b and c) and an outer massive companion (Kepler-56 d)Huber2013. The system is dynamically distinctive in three respects: (i) the host star has evolved off the main sequence and possesses a deep convective envelope, (ii) the inner planets reside at small semi-major axes where stellar tides are strongly enhanced, and (iii) the system includes a distant, massive companion capable of secularly perturbing the inner orbits. These characteristics make Kepler-56 an ideal laboratory for investigating tidal decay and planetary engulfment during post–main sequence stellar evolution.

Stellar parameters

Kepler-56 is an evolved low-mass red-giant-branch star. Asteroseismic analyses indicate that the star has already undergone significant radial expansion compared to its main-sequence phase. The current stellar radius is several times the solar radius, implying that the strength of equilibrium tides acting on close-in planets is greatly amplified. The presence of a substantial convective envelope ensures efficient tidal dissipation through turbulent viscosity, placing the system firmly in the convective-envelope tidal regime. Huber2013

Planetary architecture

The two inner planets, Kepler-56 b and c, orbit well inside 0.2 AU and are therefore subject to strong tidal torques from the expanding host star. Both orbits are nearly circular, consistent with long-term tidal circularisation. The outer companion, Kepler-56 d, lies on a much wider orbit with a moderate eccentricity and a mass in the giant-planet regime. This outer body does not participate directly in tidal decay but can influence the inner system through long-term secular interactions.Rasio1996

Adopted system parameters

Table 1 summarises the stellar and planetary parameters adopted throughout this work. These values are representative of current observational constraints and are sufficient for order-of-magnitude and evolutionary timescale estimates relevant to tidal decay and engulfment.

Implications for tidal evolution

Zahn1977 The tidal evolution of the Kepler-56 system is primarily governed by the dimensionless ratio $R_\star/a$ for the inner planets. At the present evolutionary stage, both planets satisfy $R_\star/a$0.1, implying that tidal decay timescales are highly sensitive to further stellar expansion. As the star continues its ascent

Table 1: Adopted parameters of the Kepler-56 system used in this work.

Quantity	Symbol	Value
Host star		
Stellar mass	$M_\star$	~ 1.3 $M_\odot$
Stellar radius	$R_\star$	~ 4.2 $R_\odot$
Effective temperature	$T_{\rm eff}$	~ 4800 K
Evolutionary state		Red giant branch
Convective envelope mass	$M_{\rm env}$	~ 0.3–0.5 $M_\odot$
Planet b		
Planet mass	$M_{\rm b}$	~ 22 $M_\oplus$
Planet radius	$R_{\rm b}$	~ 0.58 $R_{\rm Jup}$
Orbital period	$P_{\rm b}$	~ 10.5 d
Semi-major axis	$a_{\rm b}$	~ 0.10 au
Eccentricity	$e_{\rm b}$	≈ 0
Planet c		
Planet mass	$M_{\rm c}$	~ 0.6 $M_{\rm Jup}$
Planet radius	$R_{\rm c}$	~ 0.87 $R_{\rm Jup}$
Orbital period	$P_{\rm c}$	~ 21.4 d
Semi-major axis	$a_{\rm c}$	~ 0.17 au
Eccentricity	$e_{\rm c}$	≈ 0
Outer companion (d)		
Planet mass (minimum)	$M_{\rm d}$	~ 5.6 $M_{\rm Jup}$
Orbital period	$P_{\rm d}$	~ 2.7 yr
Semi-major axis	$a_{\rm d}$	~ 2.2 au
Eccentricity	$e_{\rm d}$	~ 0.2

Along the red-giant branch and $R_\star$ increases, the tidal torque grows rapidly, Triggering runaway orbital decay and inevitable engulfment. The outer companion remains dynamically detached from direct tidal effects but may play an indirect role by exciting inclination or precession of the inner system, thereby shaping the long-term dynamical evolution prior to engulfment.

Tidal Evolution

Tidal regime for evolved stars

Tidal evolution in star–planet systems depends critically on the internal structure and evolutionary state of the host star.

For main-sequence stars with shallow convective envelopes or radiative interiors, tidal dissipation is often weak and uncertain. In contrast, once a star evolves off the main sequence and ascends the red-giant branch, it develops a deep convective envelope in which equilibrium tides are efficiently dissipated through turbulent viscosity. As a result, tidal interactions between an evolved star and close-in planets are greatly enhancedVillaver2014. The Kepler-56 host star lies firmly in this convective envelope regime. Consequently, the tidal evolution of its inner planets is dominated by equilibrium tides raised on the star, rather than by tides raised on the planets themselves. This distinction is essential, as stellar tides scale extremely steeply with the stellar radius and therefore evolve rapidly as the star expands.

Equilibrium tides in a convective envelope

For a planet of mass M_p orbiting a star of mass $M_\star$ and radius $R_\star$, the rate of change of the semi-major axis due to equilibrium tides dissipated in the stellar convective envelope can be written as

$$\left(\frac{\dot{a}}{a}\right)_{\text{tide}} = \frac{f}{\tau}\,\frac{M_{\text{env}}}{M_\star}\,q(1+q)\,\left(\frac{R_\star}{a}\right)^{8}\left(\frac{\Omega_\star}{\omega_{\text{orb}}}-1\right) \quad (1)$$

where $q = M_p/M_\star$ is the planet–star mass ratio, M_{env} is the mass of the stellar convective envelope, $\Omega_\star$ is the stellar spin angular frequency, $\omega_{\text{orb}} = 2\pi/P$ is the orbital angular frequency, and τ is the convective eddy turnover timescale accounts for the reduction in effective viscosity when the convective eddy turnover time exceeds the tidal forcing period. A commonly adopted prescription is The factor f accounts for the reduction in effective viscosity when the convective eddy turnover timescale τ exceeds the tidal forcing period. A commonly adopted prescription is

$$f = \begin{cases} \left(\dfrac{P}{2\tau}\right)^{2}, & \tau > P/2, \\ 1, & \tau \le P/2 \end{cases} \quad (2)$$

The factor f accounts for the reduction in effective viscosity when the con35 vective eddy turnover timescale exceeds the tidal forcing period.

Convective turnover timescale

The convective turnover timescale τ depends on the stellar structure and luminosity and may be approximated as

$$\tau = \left[\frac{M_{\text{env}}\,(R_\star - R_{\text{env}})^2}{3\,L_\star}\right]^{1/3}, \quad (3)$$

Where R_{env} is the radius at the base of the convective envelope and $L_\star$ is the stellar luminosity. As the star ascends the red-giant branch, both M_{env} and $R_\star$ increase, while $L_\star$ rises rapidly, leading to systematic evolution of the convective turnover timescale τ and hence the tidal dissipation rate.

Direction of orbital evolution

For close-in planets around evolved stars, the orbital angular frequency typically satisfiesVillaver2014 where R_{env} is the radius at the base of the convective envelope and $L_\star$ is the stellar luminosity. As the star ascends the red-giant branch, both M_{env} and $R_\star$ increase, while $L_\star$ rises rapidly, leading to systematic evolution of the convective turnover timescale τ and hence the tidal dissipation rate 15 and Eq. (1) reduces to

$$\dot{a} \simeq -a\,\frac{f}{\tau}\,\frac{M_{\text{env}}}{M_\star}\,q(1+q)\,\left(\frac{R_\star}{a}\right)^{8}. \quad (4)$$

where R_{env} is the radius at the base of the convective envelope and $L_\star$ is the stellar luminosity. As the star ascends the red-giant branch, both M_{env} and $R_\star$ increase, while $L_\star$ rises rapidly, leading to systematic evolution of the convective turnover timescale τ and hence the tidal dissipation rate.

Runaway tidal decay and engulfment

R_{env} is the radius at the base of the convective envelope and $L_\star$ is the stellar lu23 minosity. As the star ascends the red-giant branch, both M_{env} and $R_\star$ increase, while $L_\star$ rises rapidly. This leads to systematic evolution of the convective turnover timescale τ and, consequently, the tidal dissipation rate the orbital decay accelerates rapidly, leading to a runaway inspiral once a critical stellar radius is reached. In this regime, the remaining lifetime of a close-in planet can be orders of magnitude shorter than the stellar evolutionary timescale. Engulfment need not coincide exactly with the moment when the stellar photosphere reaches the orbital radius. Enhanced tidal drag, atmospheric interaction, and mass loss can destroy the planet at radii larger than the stellar surface. Thus, orbital decay calculations provide a natural explanation for the apparent absence of very close-in planets around red-giant stars.

Application to the Kepler-56 system

Both inner planets in Kepler-56 orbit at sufficiently small semi-major axes that the ratio $R_\star/a$ is already no negligible. As the star continues its red-giant evolution, the tidal decay timescales for these planets are expected to decrease sharply, making eventual engulfment unavoidable. The system therefore represents a snapshot of planetary systems in the final stages preceding destruction by stellar evolution.Rasio1996,Villaver2014. The outer companion remains dy namically detached from direct tidal interaction but may influence the timing and geometry of engulfment through secular perturbations of the inner orbits, a topic we discuss further in Section 4.

Engulfment Scenario

Characteristic tidal decay timescale

A useful way to quantify the fate of close-in planets around evolved stars is through the characteristic tidal decay timescale, The characteristic tidal decay timescale is defined as

$$t_{\rm tide} \equiv \left|\frac{a}{\dot{a}}\right|. \quad (5)$$

$\omega_{\rm orb} \gg \Omega_\star$ Using the equilibrium-tide expression derived in Section 3, and assuming , the timescale becomes

$$t_{\rm tide} \simeq \frac{\tau}{f}\,\frac{M_\star}{M_{\rm env}}\,\frac{1}{q(1+q)}\left(\frac{a}{R_\star}\right)^8 \quad (6)$$

The characteristic tidal decay timescale is defined as $t_{\rm tide} \equiv |a/\dot{a}|$. This implies that tidal decay is negligible while the star is compact, but becomes catastrophic once the stellar radius grows to a significant fraction of the planetary orbitMustillVillaver2012.

Runaway inspiral during red-giant expansion

As a star ascends the red-giant branch, its radius increases monotonically on a nuclear timescale, while the convective envelope deepens. Both effects act in the same direction, sharply reducing the tidal decay timescale $t_{\rm tide}$. Consequently, once a planet enters the regime where $R_\star/a$0.1, orbital decay accelerates rapidly and enters a runaway phase. In this regime, the remaining lifetime of the planet is no longer controlled by stellar evolution but by tidal dissipation itself. The in spiral time from a given semi-major axis to engulfment can be orders of magnitude shorter than the red-giant lifetime, implying that systems observed in this phase represent a brief but physically important window.Rasio1996

Criterion for engulfment

Engulfment is often naively defined as the instant at which the stellar photospheric radius becomes equal to the orbital radius, $R_\star = a$. In practice, destruction can occur earlier due to a combination of tidal drag, enhanced stellar winds, and interaction with the extended stellar atmosphere. A practical engulfment criterion may be written as $a\alpha R_\star$, where α is a factor of order unity, typically in the range $\alpha \sim 1$–2, depending on the treatment of atmospheric drag and mass loss. Once this condition is satisfied, the remaining inspiral time becomes extremely short, and the planet is effectively doomedVillaver2014.

Differential fate of multiple planets

In multi-planet systems, the engulfment sequence is controlled primarily by the ordering of semi-major axes. Inner planets experience runaway decay first and are destroyed earlier, while outer planets may survive until later evolutionary stages or escape engulfment altogether. For the Kepler-56 system, the two inner planets occupy sufficiently different orbits that their engulfment times are expected to be separated. Planet b, being closer to the star, should enter the runaway regime earlier and be destroyed first, followed by planet c as the stellar radius continues to increase. This sequential engulfment is a natural outcome of tidal theory and does not require fine tuningRasio1996.

Angular momentum transfer and stellar response

As a planet spirals inward, its orbital angular momentum is transferred to the stellar envelope. Although the total angular momentum carried by a single planet is small compared to that of the star, the deposition of this angular momentum into a slowly rotating convective envelope can produce observable effects, such as temporary spin-up or enhanced surface rotation. Evaluated near the point of destruction Time becomes extremely short, and the planet is effectively doomed. For sufficiently massive planets, this process can measurably alter the stellar rotation profile and has been invoked to explain rapid rotators among red giantsZahn1977.

Implications for observed planet populations

The tidal decay and engulfment process described above provides a natural explanation for the observed scarcity of close-in planets around red-giant stars. Systems like Kepler-56 are therefore not anomalies, but rather rare snapshots of a short-lived evolutionary phase. The detection of such systems supports the view that many close-in planets formed around main-sequence stars are ultimately destroyed as their hosts evolveVillaverLivio2009.

Discussion

Kepler-56 as a benchmark system for planetary can3 nibalism

The Kepler-56 system occupies a particularly important position among known star–planet systems because it captures a short-lived but physically decisive evolutionary phase. Unlike statistical inferences drawn from planet occurrence rates around evolved stars, Kepler-56 provides a concrete, well-characterised example in which tidal decay and planetary destruction are expected to be actively operating. The combination of a significantly expanded stellar radius, deep convective envelope, and surviving close-in planets places the system at the threshold between long-term stability and inevitable engulfment. What distinguishes Kepler-56 from many other evolved systems is the availability of asteroseismic constraints on the host star. These constraints sharply reduce uncertainties in stellar mass, radius, and evolutionary state, allowing tidal decay calculations to be anchored to physically realistic parameters rather than free scaling assumptions. As a result, Kepler-56 serves as a benchmark system against which tidal dissipation prescriptions for evolved stars can be testedLilloBox2014.

Sequential engulfment of multiple planets

A practical criterion for engulfment may be written as $a\alpha R_{*}$, where α is a factor of order unity, typically in the range $\alpha \sim 1$–2, depending on the treatment of atmospheric drag and mass loss. Once this condition is met, the remaining inspiral time becomes extremely short, and the planet is effectively doomed. This is the sequential engulfment of planets ordered by orbital distance. In Kepler-56, the two inner planets occupy sufficiently different semi-major axes that their tidal decay timescales differ by orders of magnitude once the star enters the runaway regime. The innermost planet is therefore expected to be destroyed first, followed by the second inner planet as stellar expansion continues. This sequential destruction does not require finely tuned parameters or exotic mechanisms. It arises generically from equilibrium-tide theory applied to stars with deep convective envelopes and provides a straightforward explanation for the scarcity of compact multi-planet systems around red-giant stars. Systems observed with a single surviving close-in planet around evolved hosts may therefore represent the remnants of originally richer planetary architecturesVillaverLivio2009.

Role of the outer companion

The presence of a massive outer companion in the Kepler-56 system plays an important dynamical role in shaping the architecture of the inner planetary system. Radial-velocity observations have established the existence of a distant, non-transiting giant planet whose orbit lies well beyond the tidal influence of the host star Otor2016. Although this outer companion does not participate directly in tidal decay, it can exert long-term secular torques on the inner planets, leading to inclination excitation and nodal precession. Detailed dynamical studies have shown that such secular perturbations are capable of producing the large spin–orbit misalignment observed in the Kepler-56 system Li2014. In this framework, the outer companion drives the inner planetary orbits away from alignment with the stellar spin axis while maintaining near-coplanarity between the inner planets themselves. More generally, theoretical work has demonstrated that inclined external companions can naturally generate and sustain spin–orbit misalignments in multiplanet systems through secular interactions Lai2018. In the context of planetary engulfment, the outer companion may therefore influence not only the timing but also the geometry of engulfment events by maintaining inclined inner orbits prior to tidal inspiral. This provides a natural pathway linking secular dynamics, tidal evolution, and the observed core–envelope spin misalignment in Kepler-56. The presence of a massive outer companion in Kepler-56 adds an important dynamical dimension to the system. While the outer planet is too distant to experience significant tidal decay, it can influence the inner system through long-term secular interactions. Such perturbations may excite mutual inclinations, induce nodal precession, or maintain slight eccentricities that enhance tidal dissipation in the inner planets. Although tidal decay alone is sufficient to guarantee eventual engulfment of the inner planets, the outer companion may affect the timing and geometry of engulfment. In particular, inclination excitation could lead to oblique engulfment trajectories or influence the distribution of angular momentum deposited into the stellar envelope. Kepler-56 therefore illustrates how tidal evolution and secular dynamics can operate simultaneously, rather than in isolation.

Angular momentum deposition and stellar response

Planetary engulfment transfers orbital angular momentum to the stellar enve27 lope. In red-giant stars with slowly rotating convective envelopes, even a modest amount of deposited angular momentum can produce observable consequences, such as temporary spin-up or enhanced surface rotation. While the angular momentum carried by individual planets in Kepler-56 is small compared to the total stellar angular momentum, its deposition into a low-inertia envelope may still lead to measurable effects. Such processes have been proposed as explanations for anomalously rapid rotation observed in a subset of red-giant stars. Kepler 56 thus provides a physically motivated pathway linking close-in planets, tidal decay, and stellar rotational anomalies. Future observations of surface rotation and internal rotation profiles in evolved stars may offer indirect confirmation of ongoing or past engulfment eventsZahn1977.

Implications for the evolved-star planet population

The tidal-decay framework applied to Kepler-56 has broader implications for exoplanet demographics. The observed deficit of short-period planets around red-giant stars is a natural outcome of tidal destruction rather than a failure of planet formation. Systems like Kepler-56 are expected to be rare not because engulfment is uncommon, but because the phase during which closein planets survive around an expanded star is short. From this perspective, the Kepler-56 system represents a fleeting snapshot of a universal evolutionary pathway. A substantial fraction of close-in planets detected around mainsequence stars are expected to undergo tidal decay and eventual engulfment as their host stars evolve off the main sequence and ascend the red-giant branch VillaverLivio2009,Villaver2014. The system therefore provides a valuable empirical anchor for connecting main-sequence exoplanet populations to the observed 9 properties of evolved stars.

Limitations and future directions

While the present analysis captures the dominant physics of tidal decay and planetary engulfment, several sources of uncertainty remain. In particular, the efficiency of tidal dissipation in deep convective envelopes is still imperfectly constrained, and different prescriptions can lead to significant variations in predicted decay timescales Zahn1977,VillaverLivio2009. In addition, the detailed structure of extended stellar atmospheres during late evolutionary stages, as well as the interaction between tidal decay and stellar mass loss, can modify the onset and progression of engulfment Villaver2014. Incorporating full stellar-evolution tracks and coupling them self-consistently to orbital evolution models will therefore be essential for refining quantitative engulfment timescale estimates. Future observations will play a critical role in constraining these processes. In particular, asteroseismic studies of evolved planet-hosting stars provide precise measurements of stellar internal structure and evolutionary state, enabling tighter constraints on tidal models Huber2013. Complementary surveys targeting planets around subgiant and red-giant stars will expand the sample of systems similar to Kepler-56, allowing tidal theories to be tested systematically across a broad range of stellar masses and evolutionary stages VillaverLivio2009,Villaver2014

Core–envelope spin misalignment and envelope spin-up

An additional peculiarity of the Kepler-56 system is the anomalously rapid rotation of the stellar convective envelope and the observed misalignment between the spin axis of the stellar core and that of the outer envelope. Standard single-star evolutionary models predict slow envelope rotation and approximate alignment between core and envelope angular momentum vectors in red-giant stars. These expectations are clearly violated in Kepler-56. Recent work by Tokuno2025 has shown that planetary engulfment provides a natural explanation for both features. During engulfment, the orbital angular momentum of a close-in planet is deposited predominantly into the convective envelope, which has a comparatively low moment of inertia. Even a single engulfment event can therefore spin up the envelope by more than an order of magnitude relative to typical red-giant rotation rates. If the engulfed planet's orbit is inclined with respect to the stellar spin axis—an outcome expected in systems with outer massive companions—the angular momentum added to the envelope is misaligned with the pre-existing stellar rotation. Because the coupling between the stellar core and convective envelope operates on timescales longer than the engulfment process, the core largely preserves its original spin orientation while the envelope rapidly reorients and accelerates. This naturally leads to a longlived core–envelope spin misalignment. In the Kepler-56 system, the presence of a massive outer companion provides a plausible mechanism for maintaining inclined inner orbits prior to engulfment. The observed rapid envelope rotation and spin-axis misalignment may therefore be interpreted as fossil signatures of one or more past planetary engulfment events, reinforcing the interpretation of Kepler-56 as a system undergoing planetary cannibalism.

Conclusions

We have examined the Kepler-56 as a physically well-constrained example of planetary cannibalism driven by post–main-sequence stellar evolution. Owing to its evolved red-giant host, deep convective envelope, and surviving close-in planets, Kepler-56 provides a rare observational snapshot of a system approaching the final stages of tidal destruction. Our main conclusions are as follows: Tidal decay around red giants is inevitable for close-in planets. Once a host star ascends the red-giant branch, the rapid increase in stellar radius and the presence of a deep convective envelope dramatically enhance equilibrium tidal dissipation. The resulting orbital decay exhibits a steep dependence on $(R_*/a)^8$, leading to runaway inspiral for planets at sufficiently small semi-major axes. Sequential engulfment is a natural outcome of tidal theory. In multi-planet systems such as Kepler-56, planets are destroyed in order of increasing orbital distance. The innermost planet enters the runaway decay regime first and is engulfed earlier, followed by outer close-in companions as stellar expansion proceeds. This behavior does not require fine tuning and follows directly from standard tidal prescriptions. Kepler-56 represents a short-lived but physically important evolutionary phase. Systems in which close-in planets coexist with an expanded red-giant host are expected to be intrinsically rare, not because engulfment is uncommon, but because the survival time of such configurations is short. Kepler-56 therefore captures a fleeting stage that bridges compact main-sequence planetary systems and the planet-depleted populations observed around red giants. Planet engulfment contributes to stellar angular-momentum evolution. The transfer of orbital angular momentum from decaying planets to the stellar envelope may produce observable signatures, such as enhanced surface rotation in evolved stars. Kepler-56 offers a physically motivated pathway connecting close-in planets to rotational anomalies reported in subsets of red-giant stars. Broader implications for exoplanet demographics. The absence of short-period planets around evolved stars can be understood as a consequence of tidal destruction rather than suppressed planet formation. Kepler-56 thus provides a concrete anchor linking main-sequence exoplanet populations to their eventual fate during stellar evolution. In summary, Kepler-56 stands as one of the clearest known examples of planetary cannibalism in action. Its well-determined stellar properties and dynamically structured planetary system make it a benchmark for testing tidal dissipation theories and for understanding the ultimate fate of close-in planets around evolving stars. The present analysis highlights the Kepler-56 system as a representative example of late-stage dynamical evolution in planetary systems orbiting evolved stars. By examining the orbital architecture within the framework of angular-momentum redistribution and tidal interaction, this study demonstrates how stellar evolution can drive progressive orbital decay and ultimately lead to planetary engulfment. The Kepler-56 system therefore provides an important observational laboratory for understanding the mechanisms of planetary cannibalism around post-main sequence stars. The dynamical interpretation presented here places Kepler-56 in a broader context that includes other systems undergoing tidal evolution, 14 thereby offering insight into the long-term fate of close-in planets as their host stars evolve off the main sequence.

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There is no conflict of interest financial or otherwise with anybody

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During the preparation of this work the Author used ChatGPT and deepseek in order to reason. After using this service the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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The author collected data regarding LOD (Length of Earth Day) from popular science books by Isaac Asimov, George Gamow and Carl Sagan (COSMOS). After receiving the Press Release of NASA on Silver Jubilee Anniversary of Man's landing on Moon on 20th July 1994 that Moon has receded by 1 meter in last 25 years, author redid the Earth-Moon analysis and presented at 82nd Session of Indian Science Congress at Jadavpur University,Kolkata,in 1995. The Author further elaborated the analysis of the E-M system and presented the Kinematic Model of the E-M System at World Science Congress,Houston, in 2002. In 2004, at the 35th Scientific assembly of COSPAR, Author presented the New Perspective on Birth and Evolution of our Solar System and exo-planetary systems. In 2012, at the 39th Scientific Assembly at Mysore,India, paper B03- 0011-12, "Iapetus sub-satellite revisited and it reveals the celestial body formation in Primary Centric Framework. In 2017,at CELMEC VII, Rome, the Advanced Kinematic Model of Earth-Moon System was presented and finally published in Journal Of Geography And Natural Disasters where the perfect match between the Observed LOD curve and Theoretical LOD curve was achieved. A sequential paper on the Past, Present and Future of Earth-Moon Globe Orbit Dynamics and its habitability was published in JMTCM. The present paper is a paper in the same series where the author is trying to study different binary systems in Primary-Centric Framework. A paper on "The evolution of Black Hole Binaries- from birth to final coalescence" has been published. A paper on a wide binary star system HD80606A+HD80607B and its exoplanet HD808606b in the Primary Centric Framework has been published. In a paper under peer review, a 51 Pegassi b exoplanet is studied in a Primary-centric framework. In a paper 11 exoplanetary systems are studied to prove the tenants of Primary-centric. Stars in the neighbor-hood of Sagittarius A* (the supermassive black hole anchoring the Milky Way) is under peer review. Another paper on Supermassive Black Hole Binary OJ287 is under peer review. A paper on a lemon shape

exo-planet with atmospheric carbon is under review.This paper deals with the conditions which lead to the engulfment of exo-planets in post main sequence stage of planet hosting stars..

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Data Availability

The data sets generated during the current study are avaiable from the corre7 sponding Author on reasonable request.

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