[illegible]

[illegible] — 2026[illegible]7[illegible]

Robert Galida
[illegible]

[illegible]

[illegible]

[illegible]

> [illegible]

[illegible] σ_{excess} [illegible] $D_\infty = \int \sigma_{excess}\, dt$ [illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]

[illegible]——[illegible]——[illegible]

[illegible] [illegible]

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1. [illegible]

[illegible]

[illegible]

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

[illegible]—[illegible]

[illegible]

[illegible] [illegible]—[illegible]—[illegible]

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2. [illegible]

2.1 [illegible]

[illegible]（Arnold, 1989）[illegible]

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

2.2 [illegible]

[illegible]
Onsager (1931) [illegible] Prigogine (1947)[illegible]

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

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2.3 □□□□□

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3. □□□□□□□

3.1 □□□□□

□□ Galida (2026c)□□□□□□□□□□□$\sigma_{excess}(x)=\sigma(x)-\sigma_{ss}(x)$

□□ $\sigma(x)$ □□□□□□□$\sigma_{ss}(x)$ □□□□□□□□□□□□

□□□□□□□□□□□□□$\sigma_{excess}=\frac{\dot{E}_{irrev}-\dot{E}_{ss}}{T_{eff}}$□□

□□ $\dot{E}_{irrev}$ □□□□□□□□□□□□$\dot{E}_{ss}$ □□□□□□□□□□□□□□□T_{eff} □□□□□□

□□□□□□ **$\sigma_{excess}\to 0$** □□

3.2 □□□□□□

□□	□ E˙E˙	□□ E˙ssE˙ss□	σexcessσexcess□
□□□□	LGW(e)LGW□(e)	LGW(e=0)LGW□(e=0)	[LGW(e)−LGW(0)]/Teff[LGW□(e)−LGW(0)]/Teff□
□□□□	Ptide(Ω,e)Ptide□(Ω,e)	Ptide(Ω=n,e)Ptide□(Ω=n,e)	[Ptide(Ω,e)−Ptide(n,e)]/Teff[Ptide□(Ω,e)−Ptide□(n,e)]/Teff□
□□□	LdiskLdisk□	Ldisk, steadyLdisk, steady□	[Ldisk−Ldisk, ss]/Teff[Ldisk−Ldisk, ss□]/Teff□

3.3 □□□□□

□□ **1**□□□□□□□□□□ □□□□□□ T>0T>0□DT(x)=∫0Tσexcess(ϕt(x)) dtDT(x)=∫0T□σexcess□(ϕt□(x))dt

□□□□□□□□□□□□D∞(x)=∫0∞σexcess(ϕt(x)) dtD∞□(x)=∫0∞□σexcess□(ϕt(x))dt

□□□ D∞(x)D∞□(x) □□□□□□□□□□□□□□□□□□□——□□□□□□□□□□□□□

□□□□□□□□□□ □□□ σexcess=[LGW(e)−LGW(0)]/Teffσexcess□=[LGW(e)−LGW□(0)]/Teff□ □□

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4. □□□□

4.1 □□

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4.2 □□□□

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4.3 Peters & Mathews □□

□□□□□□□□□□□□□□□□□ Peters & Mathews (1963) □□□□□□□□□□□□□□□□□ Peters (1964) □□□dadt=−645G3m1m2(m1+m2)c5a3(1−e2)7/2(1+7324e2+3796e4)dtda=−564□c5a3(1−e2)7/2G3m1□m2□(m1□+m2□)□(1+2473□e2+9637e4)dedt=−30415G3m1m2(m1+m2)c5a4(1−e2)5/2e(1+121304e2)dtde=−15304□c5a4(1−e2)5/2G3m1□m2□(m1□+m2□)□e(1+304121□e2)

□□□□□ □□□ e→0e→0 □□σexcess=LGW(e)−LGW(0)Teffσexcess□=Teff□LGW□(e)−LGW□(0)□

□□□ e→0e→0 □□□□□ de/dtde/dt □□□ ee □□□□□□□□□□□□□□□□□□□□□□□□□□□□□

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5. □□□□

5.1 [illegible]

[illegible]

[illegible] Carroll (2004)[illegible]Schutz (2009)[illegible]Wald (1984) [illegible] Misner, Thorne & Wheeler (1973)[illegible]

5.2 [illegible]

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	$\sigma_{\text{excess}} = [L_{\text{GW}}(e) - L_{\text{GW}}(0)]/T_{\text{eff}}$

5.3 [illegible]

[illegible] $D_\infty = \int_0^\infty \sigma_{\text{excess}}(t)\,dt = \int_0^\infty \frac{L_{\text{GW}}(e(t)) - L_{\text{GW}}(0)}{T_{\text{eff}}}\,dt$

[illegible]

[illegible] τ [illegible] D_∞ [illegible] $\kappa = \frac{1}{\tau} \propto \frac{1}{D_\infty}$

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6. [illegible]

6.1 [illegible]

[illegible]

[illegible]

6.2 □□□□

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□□	□□□□□□□□
□□	$\sigma_{excess}=[P_{tide}(\Omega,e)-P_{tide}(\Omega=n,e)]/T_{eff}$

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6.3 □□□□□□□□

□□□□□□□□□□□□□□□□□□□□□□□□□Murray & Dermott, 1999□□$\tau_{lock}\approx\frac{2}{21}\frac{Q}{k_2}\frac{m}{M}\left(\frac{a}{R}\right)^6\frac{1}{\Omega}$□

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- Q □□□□□□□
- k_2□ □ Love □
- m □□□□□□
- M □□□□□□
- a □□□□
- R □□□□□□
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□□□□□□□□□□□□□□□□□□□□□□□$(a/R)^6$ □□□□□□□□

□□□ $\kappa=1/\tau_{lock}$□□□

7. □□□□

7.1 □□□□□

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7.2 □□□□

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8. □□□□□□□□□

8.1 □□□□□□□

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8.2 σ_{excess} □□□□□□□□□

□□□□□□□□□□□□□□□□□□□□□□$\sigma_{excess} = \frac{\dot{E}_{irrev} - \dot{E}_{ss}}{T_{eff}}$□□

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- $\dot{E}_{irrev}$ □□□□□□□□□□
- $\dot{E}_{ss}$ □□□□□□□□□□□□□
- T_{eff} □□□□□□□□□□

□□□□□ $\sigma_{excess} \geq 0$ □□□□□□□□□□□□□□□□□□□□□□□□□□

□□	$\dot{E}_{irrev}$	$\dot{E}_{ss}$	T_{eff}
□□□□	$L_{GW}(e)$	$L_{GW}(0)$	□□ GW □□
□□□□	$P_{tide}(\Omega, e)$	$P_{tide}(\Omega = n, e)$	□□□□□□
□□□	L_{disk}	$L_{disk,\,ss}$	□□□
□□□□	L_{GW}	0	□□□□□□□□□

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9. □□

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10. □□□□□

10.1 □□□□

□□□ □□□ κκ □□□□□□□□□□□□□□□□□□κ∝1D∞$\kappa \propto D$∞□1□

10.2 □□□□

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11. □□□□

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Q1: □□□	□□□□□□□□□(Penrose, 1965; Hawking & Ellis, 1973)
Q2: □□□	□□□□□□□□□
Q3: □□□□□	□□□□□□□□□□□□□□□□□(Zeldovich, 1972)
Q4: □□□□□	□□□□□□□□□□□□□□□□
Q5: GW □□□□	□□□□□□□□ TeffT_{eff}□ □□□□(Galida, 2026d)
Q6: □□□	□□□□□□□□□□□□□□□□(Galida, 2026d)

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12. □□

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[illegible]

[illegible]——[illegible] $D_{\infty} = \int \sigma_{excess}\, dt$——[illegible] σ_{excess} [illegible]

[illegible]

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