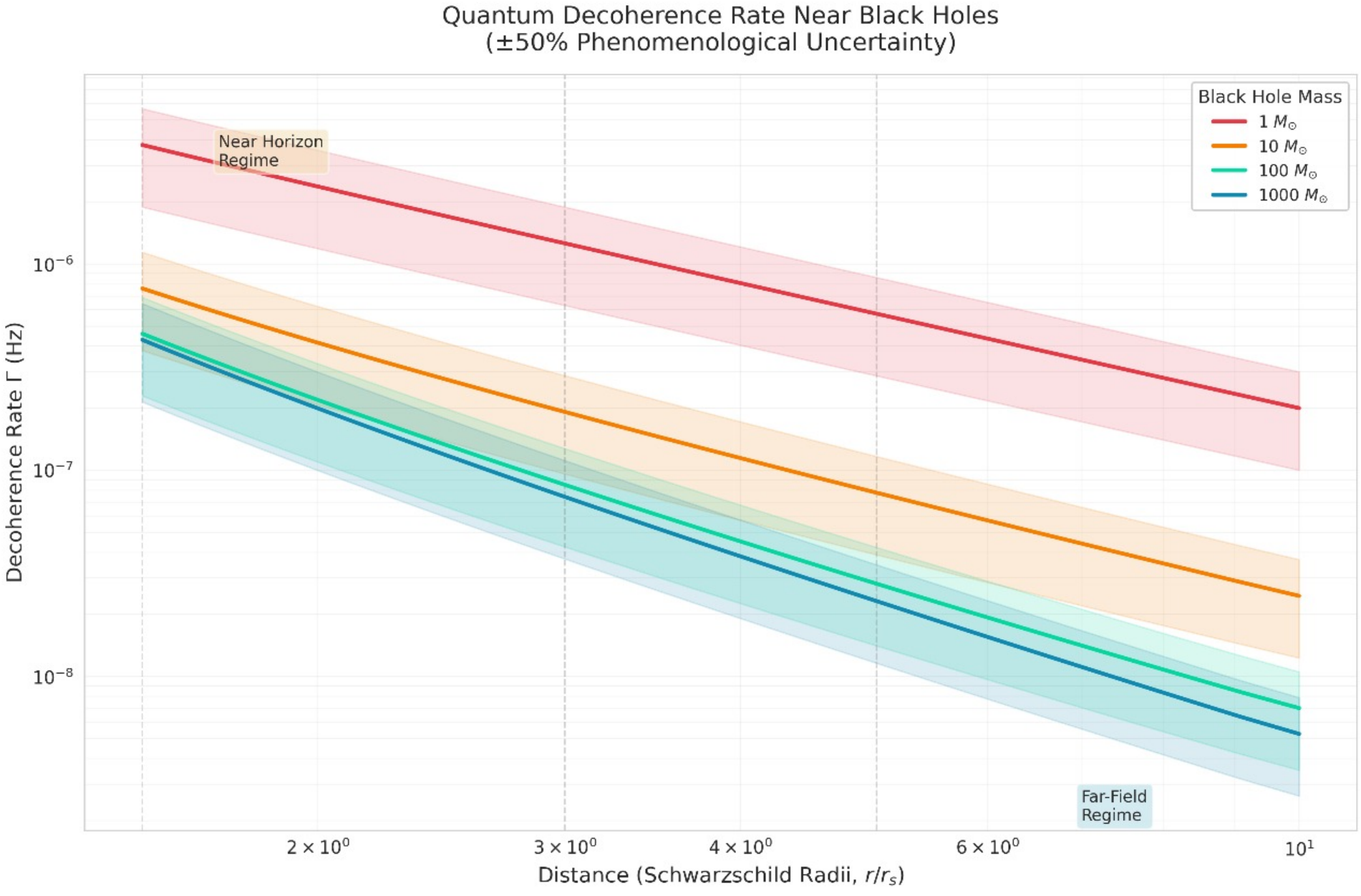


*Figure 1. Decoherence rate vs distance for black holes of varying mass. Vertical dashed lines mark transition radii (1.5, 3.0, 5.0 $r_s$). Shaded regions represent ±50% uncertainty in phenomenological coupling parameters.*

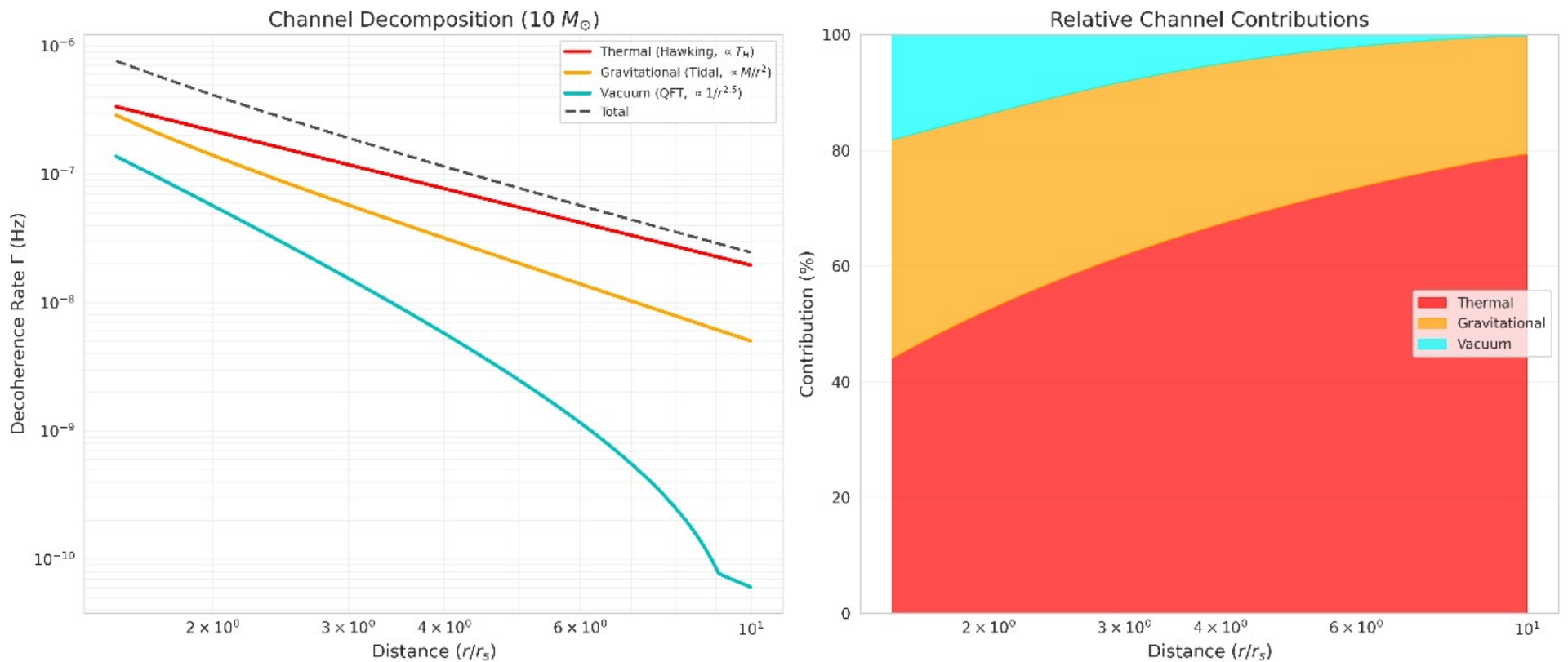


*Figure 2. (Left) Individual decoherence channels showing thermal dominance at small radii and vacuum contribution at large distances. (Right) Stacked fractional contributions sum to 100%. Crossover marks regime change from thermal to vacuum-dominated decoherence.*


*Figure 3. Exponential decay of quantum coherence from different initial distances. Circles mark characteristic decay time $\tau = 1/\Gamma$. Closer initial positions experience faster decoherence due to stronger coupling.*

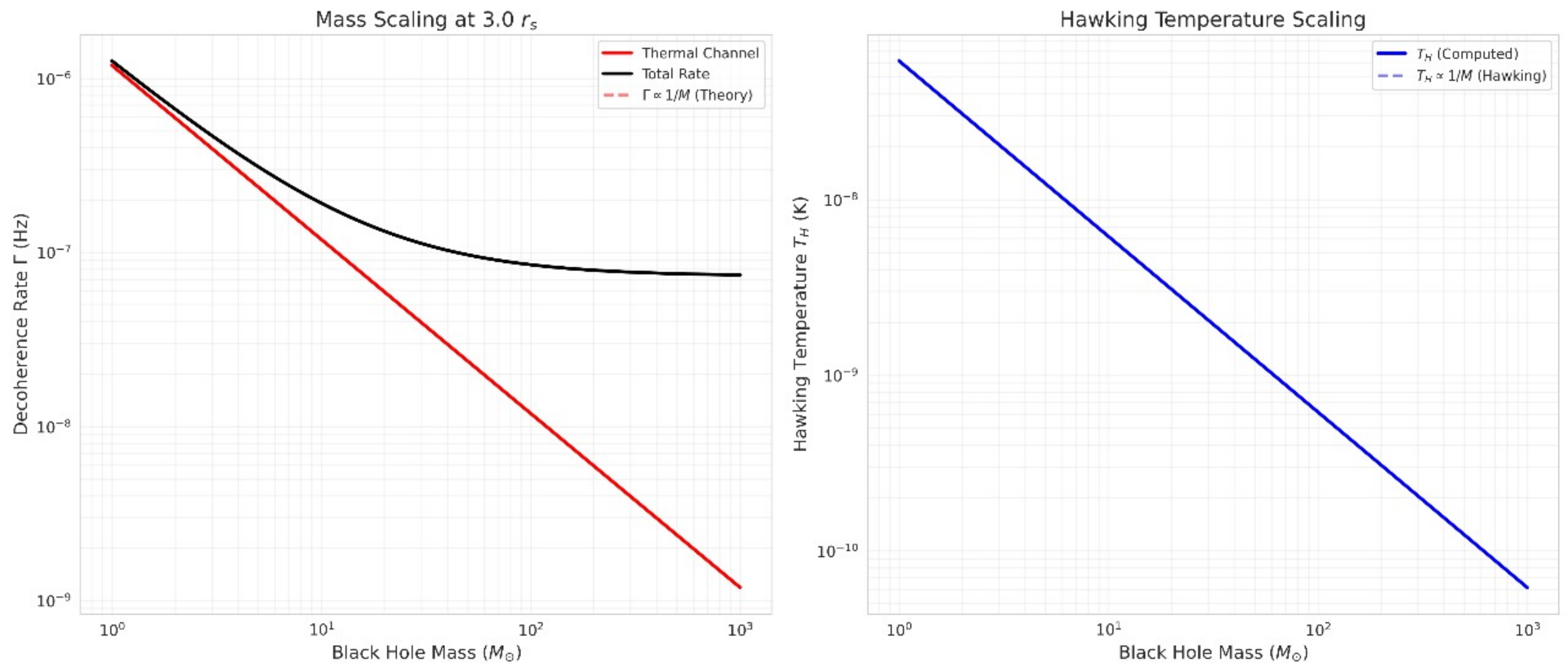


*Figure 4. (Left) Thermal decoherence rate vs black hole mass shows $\Gamma \propto 1/M$ scaling. (Right) Hawking temperature follows theoretical $T_H \propto 1/M$ prediction (dashed line). Smaller black holes have higher temperatures and stronger thermal decoherence.*

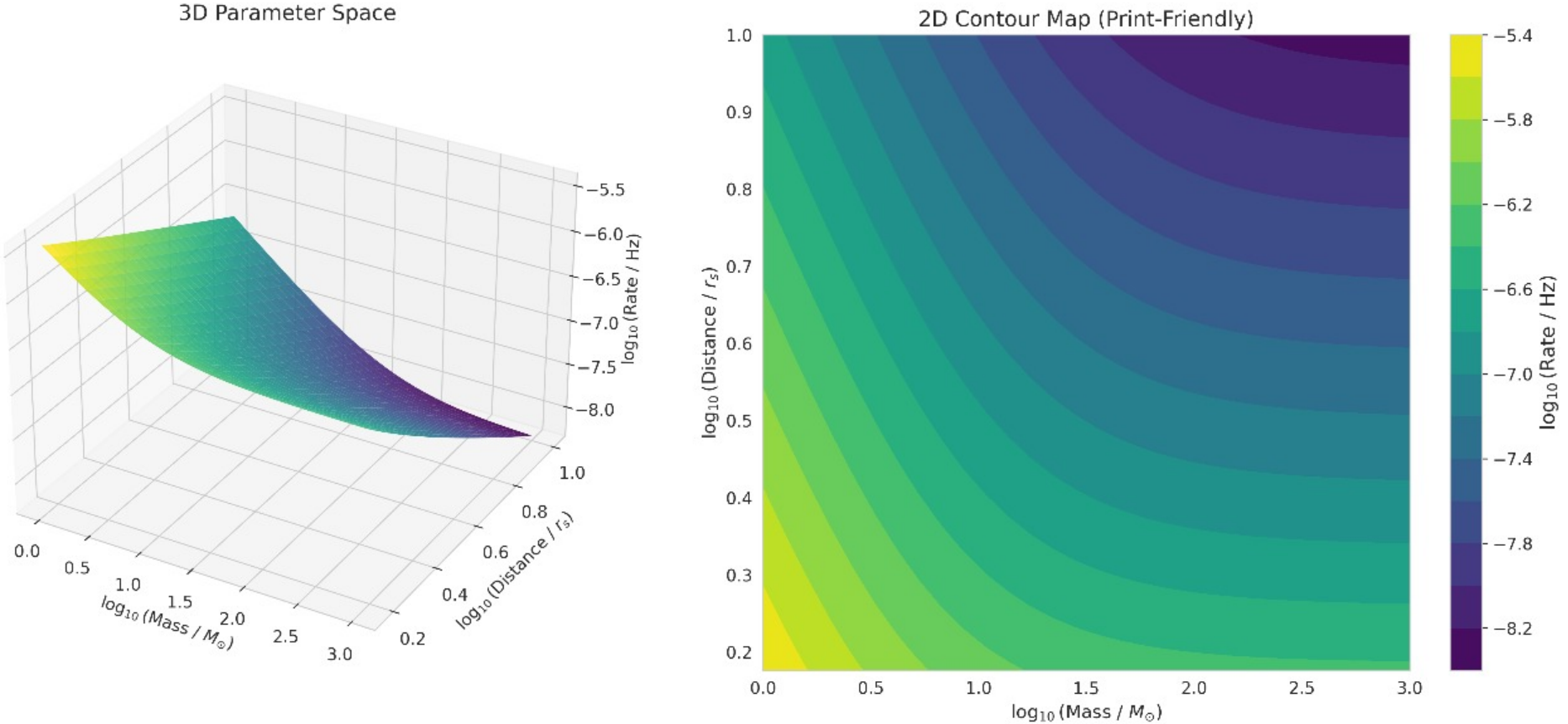


*Figure 5. Mass-distance parameter space for decoherence rate. (Left) 3D surface visualization. (Right) 2D contour map suitable for print. Color indicates $\log_{10}$ of decoherence rate in Hz.*

# Model Parameters and Physical Constants

| Physical Constant | Symbol | Value | Units |
|---|---|---|---|
| Speed of light | $c$ | $2.998 \times 10^{8}$ | m/s |
| Gravitational constant | $G$ | $6.674 \times 10^{-11}$ | $m^3/(kg \cdot s^2)$ |
| Reduced Planck constant | $\hbar$ | $1.055 \times 10^{-34}$ | J·s |
| Boltzmann constant | $k_B$ | $1.381 \times 10^{-23}$ | J/K |
| Solar mass | $M_\odot$ | $1.989 \times 10^{30}$ | kg |

| Model Parameter | Expression | Physical Basis | Uncertainty |
|---|---|---|---|
| Hawking temperature | $T_H = \hbar c^3/(8\pi k_B G M)$ | Hawking (1974) | Exact |
| Thermal coupling | $\alpha_{th} = 10^{-6}(T_H/T_0)$ | Phenomenological | ±50% |
| Gravitational coupling | $\alpha_{gr} = 5\times10^{-7}$ | Tidal estimate | ±100% |
| Vacuum coupling | $\alpha_{vac} = 2\times10^{-7}$ | QFT in curved spacetime | ±100% |
| Distance range | $r/r_s \in [1.5, 10]$ | Outside horizon | Well-defined |
| Mass range | $M \in [1, 1000]M_\odot$ | Stellar to intermediate | Well-defined |

*Note: Phenomenological couplings chosen to match order-of-magnitude estimates. Full QFT calculation would refine these parameters.*