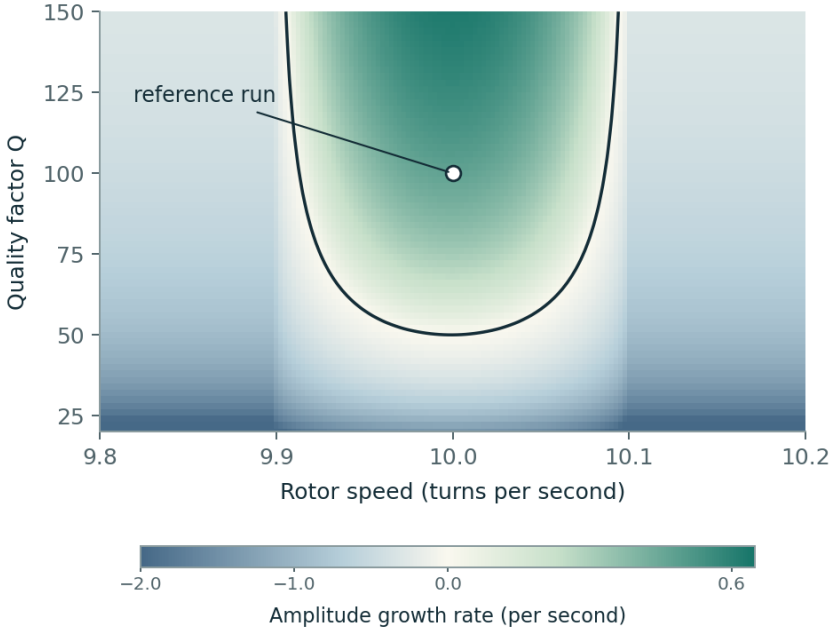
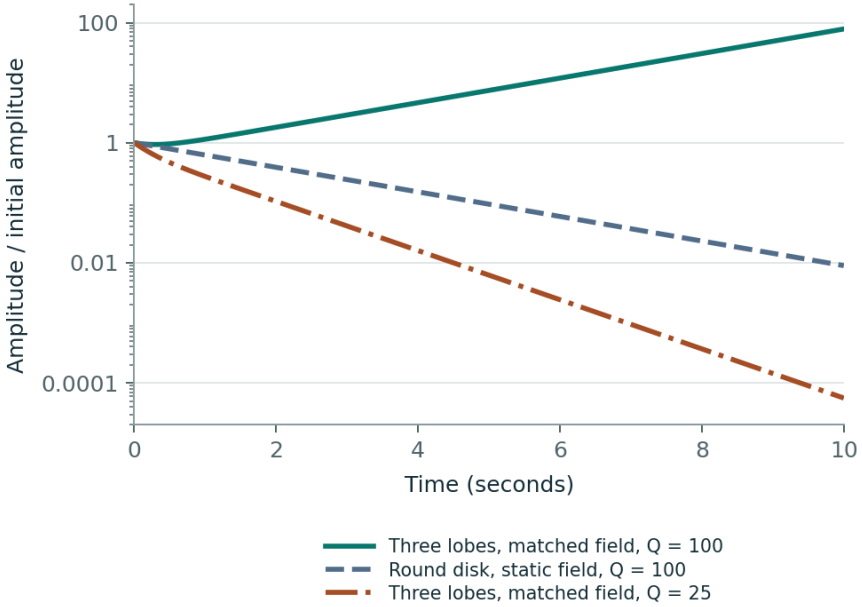
Three-lobed superconducting rotor

A Sabu-disk-inspired rotor produced a 30 Hz ring-wide modulation in a matching three-peak field. A seeded 15 Hz oscillation grew when the assumed material coupling overcame damping. The calculation provides a conditional resonance and no steady weight reduction.

Rotor speeds and damping



Evolution from the same small seed



9.913–10.086

turns per second

Growth interval at Q = 100

Q > 50.0

at 10 turns per second

Threshold for 4% stiffness modulation

2.12 seconds

per factor of e in amplitude

Reference run with Q = 100

What was assumed. The three-lobe shape was represented by its leading angular harmonic. The 15 Hz mode, its quality factor Q and its conversion of field modulation into a stiffness change were supplied to the simulation. A response frequency and linewidth measured independently in the proposed rotor would turn these conditional values into a device prediction.

How the geometry drives the mode

A sensor at one point sees three lobe passages per turn. The whole ring responds to the angular overlap between the rotor and the applied field. Both the round disk and the three-lobed rotor have the same mean angular weighting.

Ring average and stiffness

The rotor weighting has contrast ε = 0.40. The squared field around the ring has three peaks with contrast δ = 0.20. Here φ is position around the torus and Ω is rotor angular speed.

$$W = 1 + \varepsilon\cos[3(\phi - \Omega t)], \quad I = 1 + \delta\cos(3\phi)$$

$$C(t) = \langle WI \rangle_\phi = 1 + \frac{\varepsilon\delta}{2}\cos(3\Omega t)$$

The ring average gives 4% field-energy overlap modulation. To turn that into 4% modulation of a material mode's stiffness, the run assumes a dimensionless gain η = 1. Setting η = 0 removes that drive.

$$\ddot{s} + \frac{\omega_s}{Q}\dot{s} + \omega_s^2[1 + h\cos(3\Omega t)]s = 0$$

Here $h = \eta\varepsilon\delta/2$, $\omega_s = 2\pi f_s$, and s is a small, hypothesized collective-mode coordinate. ESFD equation 55 supplies a curvature $m_s^2 + u|\Psi|^2$. Converting it to a frequency also requires the kinetic coefficient. Neither it nor the response gain is calibrated for a rotor specimen.

Geometry and drive controls

At 10 turns/s and Q = 100, a positive growth rate means a seed grows. Rates below zero mean the seed fades.

Configuration	Depth h	Rate (s⁻¹)
Round, three field peaks	0%	−0.471
Three lobes, uniform field	0%	−0.471
Three lobes, two peaks	0%	−0.471
Three lobes, three peaks	4%	+0.471
Matched, conversion off	0%	−0.471
Round, external 30 Hz pulse	4%	+0.471

The pulsed round disk has the same equation as the matched three-lobed disk at this speed. An ordinary mechanical mode with those coefficients has the same response. A frequency peak alone cannot identify its physical origin. [4]

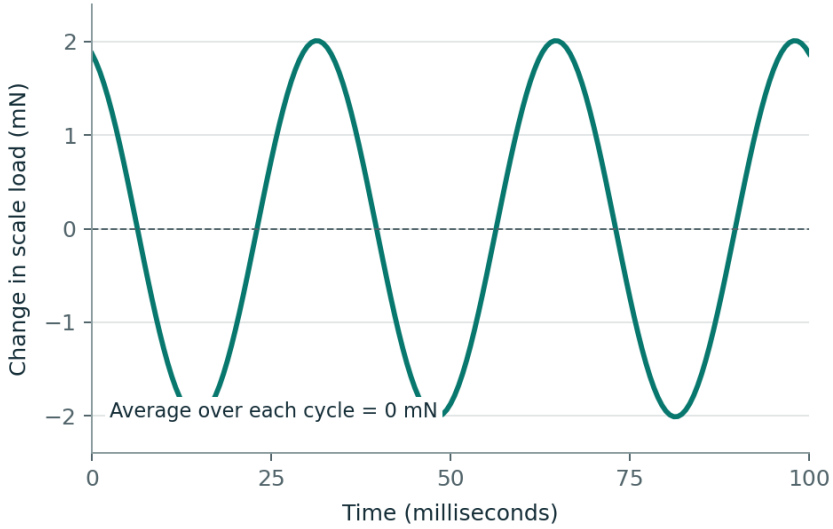
If all modulation passes through the liquid

At 30 Hz a passive fluid response attenuates the drive by $1/\sqrt{1 + (2\pi f\tau)^2}$. An assumed 5 ms lag leaves 2.91% stiffness modulation and growth continues. At 10 ms, 1.87% remains and the mode decays. The crossover is 9.19 ms at Q = 100. The liquid range and response time of the proposed mixture are unknown. Pure mercury freezes at 234.32 K, well above the 77 K YBCO benchmark. [6]

Lift inside the device and gravity outside it

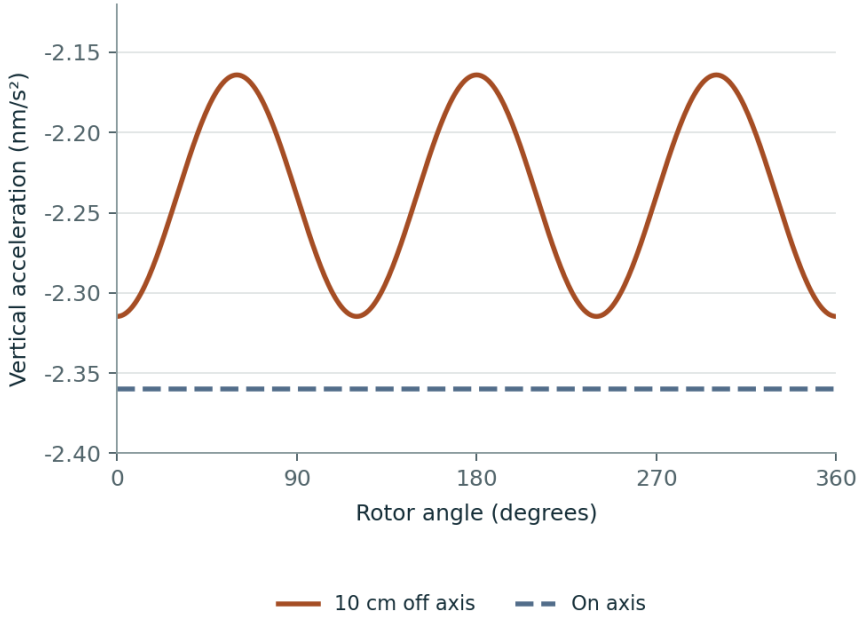
The support under the entire apparatus and a separate test mass above the rotor answer different questions. The two calculations below use ordinary mechanics and Newtonian gravity.

Whole-device load during three cycles



1 kg rotor · 22 Hz vertical suspension · 1 mN alternating internal drive

Gravity from the rotor at 10 cm height



A balance can oscillate around the true weight

In the example, an internal 1 kg part moves vertically on a 22 Hz suspension (Q = 4). Its actuator exerts 5 mN steady plus 1 mN alternating at 30 Hz. An equal reaction acts on the housing. The scale oscillates by ±2.01 mN. Its computed 20-cycle mean differs from zero by less than 10^{-12} N. For a complete stationary assembly, the mean load change equals the change of its total vertical momentum divided by the elapsed time.

Three moving lobes already attract a probe

The illustrative 1 kg ring has radius 10 cm and 30% mass variation around its rim. At a height of 10 cm, the vertical attraction is constant on axis. A probe displaced 10 cm sideways sees a 30 Hz component of 7.53×10^{-11} m/s². The calculated force always points downward. LIGO has used this same ordinary gravitational harmonic to calibrate an instrument. [5]

The material evidence

Published YBCO measurements anchor the frequency and force scales. The missing specimen-specific input is an independently resolved low-frequency mode with a measured linewidth and response to the applied field.

What published experiments measured

Magnetic excitation in YBCO [1]

Neutron scattering identified a 41 meV superconducting-state feature, equivalent to 9.91 THz. The 15 Hz example would require a distinct mode. The measurement probes a particular wave vector.

Levitation threshold of a round YBCO disk [2]

At 77 K, the reported AC threshold was 37.2 ± 0.3 mT over 10–300 Hz. The DC field estimate was 37.7 mT. The supported mass of 8.99 g corresponds to 0.088 N. This experiment measured the applied field needed for levitation.

External weight test above a spinning disk [3]

Hathaway and colleagues reported no change at about 10^{-5} of the test weight in their rotating YBCO apparatus. Its materials and geometry set the scope of that result.

What would test ESFD in this rotor

Measure the mode independently.

Measure the specimen spectrum with the rotor still, across its superconducting transition. Identify the mode and its physical origin. Its frequency, linewidth and shift with field determine the predicted speed and bandwidth.

Test the frequency before fitting the response.

For three fixed field peaks, predict $f_{rotor} \approx 2f_s/3$. Compare with a round rotor, a uniform field, and the same rotor above its transition. Measure vibration and magnetic flux independently.

Test the gravity coupling separately.

Predict a signed acceleration and its dependence on height, then compare with an independent test mass after allowing for Newtonian attraction, field leakage and vibration. ESFD equation 55 alone specifies no such force.

Sources and reproducibility

[1] Fong et al. · Physical Review Letters (1995)

[2] Carter et al. · Physica C · 10–300 Hz levitation

[3] Hathaway et al. · Physica C (2003)

[4] Carr et al. · Parametric torsional amplifier

[5] Initial results from the LIGO Newtonian calibrator

ESFD master report · superconducting extension, Eq. 55

[6] Royal Society of Chemistry · Mercury, melting point

The archive includes all inputs, six controls, the 10,626-point speed and damping sweep, simulated traces and rerunnable code. The material comparisons use published summary values. The rotor uses a prescribed field and an idealized threefold geometry.