Rayleigh radius versus Fresnel zone

These two ideas are often confused because both describe *lateral resolution limits*.

Key differences between Rayleigh radius and Fresnel zone

Concept	Rayleigh Radius	Fresnel Zone
Definition	Diffraction-based lateral resolution limit on the reflector	Region of constructive interference near the ray path
Governing physics	Diffraction (Rayleigh criterion)	Coherence / phase interference
Formula (reflector depth z)	$R_R \approx \sqrt{\lambda z}$	$R_F \approx \sqrt{\lambda z/2}$
Size	Larger (about $\sqrt{2}$times the Fresnel zone)	Smaller
Meaning	Minimum resolvable lateral reflector dimension	Area contributing significant reflection energy
Relevance	Lateral resolution of migrated images	Aperture and illumination before migration
Migration	Migration collapses the Fresnel zone toward the Rayleigh radius	Migration sharpens Fresnel zone but cannot exceed Rayleigh limit

Simple intuitive picture

Imagine a wave reflecting off a small bump on a deep reflector.

- If the bump > Rayleigh radius → you can "see" its shape.
- If the bump < Rayleigh radius → diffraction spreads the energy over a radius R_R.
- Before migration, energy arrives from a larger footprint: the Fresnel zone.
- After migration, that footprint shrinks, but never smaller than the Rayleigh radius.

Summary

The Fresnel zone is the area contributing coherent reflection energy to a receiver, while the Rayleigh radius is the fundamental diffraction-limited lateral resolution of a reflector after migration—smaller features cannot be resolved.