Nonlinear unbalanced Bessel beams (NL-UBBs) in the filamentary dynamics of self-focusing Gaussian beams

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\[ \frac{d}{d\xi} A = \frac{i}{2} \Delta \rho A + ig |A|^2 A - \gamma |A|^{2K-2} A \]

• Strong self-focusing and collapse of a Gaussian beam arrested by a small amount of nonlinear losses leads to the formation of a NL-UBB.

- NLUBB: light beam that can propagate without diffraction and without attenuation in a nonlinear medium with nonlinear losses (loss-resistant).
- This suggests that conical waves as NL-UBB could be involved in light filaments.
1) **What is a NL-UBB?**

It is a monochromatic light beam which is

a) diffraction-free

b) dissipation-resistant

\[ \text{NLSE} \]

\[ \frac{\partial A}{\partial \xi} = -\frac{i}{2} \frac{1}{\rho} \frac{\partial}{\partial \rho} \left( \rho \frac{\partial A}{\partial \rho} \right) + i g |A|^2 A - \gamma |A|^{2K - 2} \]

stationary amplitude and phase

radial profile of NL-UBB of peak intensity \( I = a^2(0) \)

Bessel-like radial profiles with infinite power

\( \frac{1}{\rho} \rho \frac{da}{d\rho} - a \left( \frac{d\phi}{d\rho} \right)^2 + 2\delta a + 2g a^3 = 0 \)

Refilling mechanism for stationarity with NLLs

\(-2\pi \rho a^2 \frac{d\phi}{d\rho} = 2\gamma 2\pi \int_0^\rho d\rho \rho a^{2K}\)

inner radial power flux

nonlinear losses

Kerr

NL losses

nonlinear axial phase shift associated to a cone angle \( \theta = (\delta/2k)^{1/2} \)

\( \delta < 1 \)

\( \delta = 10 \)

\( \delta = 100 \)
2) **Spontaneous generation of NL-UBB upon self-focusing of Gaussian beams**

Conditions for NL-UBB formation upon collapse of Gaussian beam: self-focusing length << diffraction length << nonlinear loss length, i.e. strong self-focusing with initially negligible NLLs

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**Radial intensity profile at increasing distances**

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**Inward radial power flux**

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**More information at:**
- S. Polyakov et al, JOSA B 18, 1981 (2001)