A Practical Method to Determine the Giles Parameters of a Double-Clad Ytterbium-Doped Fiber

François Brunet [1,2], Yves Taillon [2], Pierre Galarneau [2] and Sophie LaRochelle [1]

(1) Centre d'optique, photonique et lasers (COPL)
Université Laval, Québec (QC), Canada G1K 7P4

(2) INO, 2740 Einstein Street
Québec (QC) Canada G1P 4S4

Modeling Using Cross-Sections

$$\frac{dP}{dz} = N_0 \, \Gamma \left[(\sigma_a + \sigma_e) \, x(z) - \sigma_a \right] P(z)$$

N_0	Ytterbium Concentration
Γ	Overlap Integral Between the Dopant Profile And the Power Mode Profile
x	Local Fraction of Excited Ions
σ_a	Absorption Cross-Section
σ_e	Emission Cross-Section

Modeling Using Giles Parameters

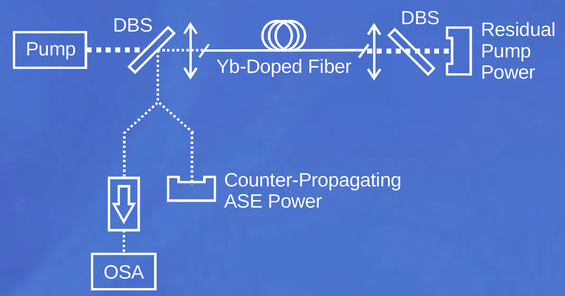
$$\frac{dP}{dz} = \left[(\alpha + g^*) \, x(z) - \alpha \right] P(z)$$

$\alpha = N_0 \, \Gamma \, \sigma_a$	Absorption coefficient of unpumped fiber
$g^* = N_0 \, \Gamma \, \sigma_e$	Gain coefficient of completely inverted fiber

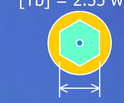
Why use Giles Parameters ?

- Direct cross-section measurement involves spectroscopic equipment not always available
- Relying on tabulated cross-section data can lead to an error of about 30%
- When using Giles parameters, there is no need to know precisely the dopant profile and the guided power mode profile
- Giles parameters correspond to absorption and gain coefficients, measurable directly on the doped fiber
- However, achieving the complete inversion required to measure de gain coefficient is in general not possible because of the small overlap between the multimode pump and the doped region

Experimental Setup

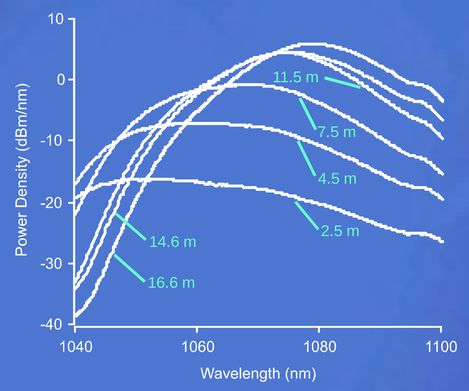


Single-mode core
INO fiber
ϕ = 6.1 μm
NA = 0.13
[Yb] = 2.55 wt%



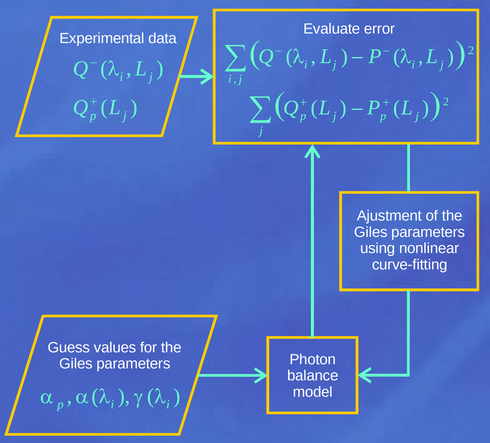
125 μm
Cladding NA = 0.35

Calibrated ASE Spectra



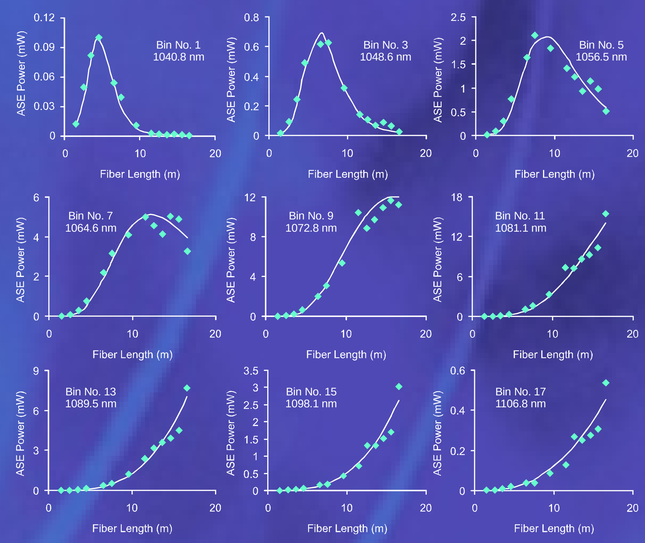
- The ASE spectrum moves towards shorter wavelengths as the fiber is cut back
- The ASE spectral content as a function of fiber length is related to the Giles parameters
- A nonlinear curve-fitting algorithm is used to calculate the Giles parameters from the ASE spectra and the residual pump power

Algorithm

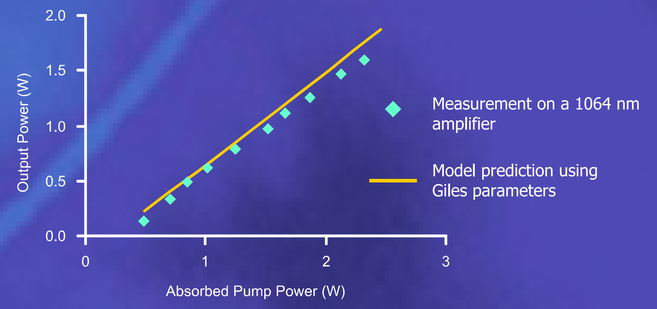


- The high number a iterations needed calls for a fast model able to compute ASE spectra
- A photon balance model is used for that purpose
- For a description of the model, one can refer to: F. Brunet et al., "Practical Design of Double-Clad Ytterbium-Doped Fiber Amplifiers Using Giles Parameters", *IEEE J. Quantum Electron.*, to be published.

Curve-Fitting Results for Various Spectral Bins



Predicting an Amplifier's Performance



CIPI's Fifth Annual Scientific Meeting, June 20-22 2004, Sherbrooke, Canada