Modelling Rayleigh Scattering Loss in Arbitrary Profile Fibers

A. Maity[1] & P. R. Watekar[1]
1. Center of Excellence, Sterlite Technologies Limited, MIDC Waluj, Aurangabad, Maharashtra, India

INTRODUCTION: Rayleigh scattering loss (RSL) is the major contributor (~80%) to fiber attenuation. RSL arises from random microscopic inhomogeneities which is directly related to dopant concentration in the host glass. Till date, RSL model for step-index fibers are reported [1,2], which is not adequate for arbitrary profile fibers. Here we present RSL model for arbitrary profile fiber with graded-index fiber as example.

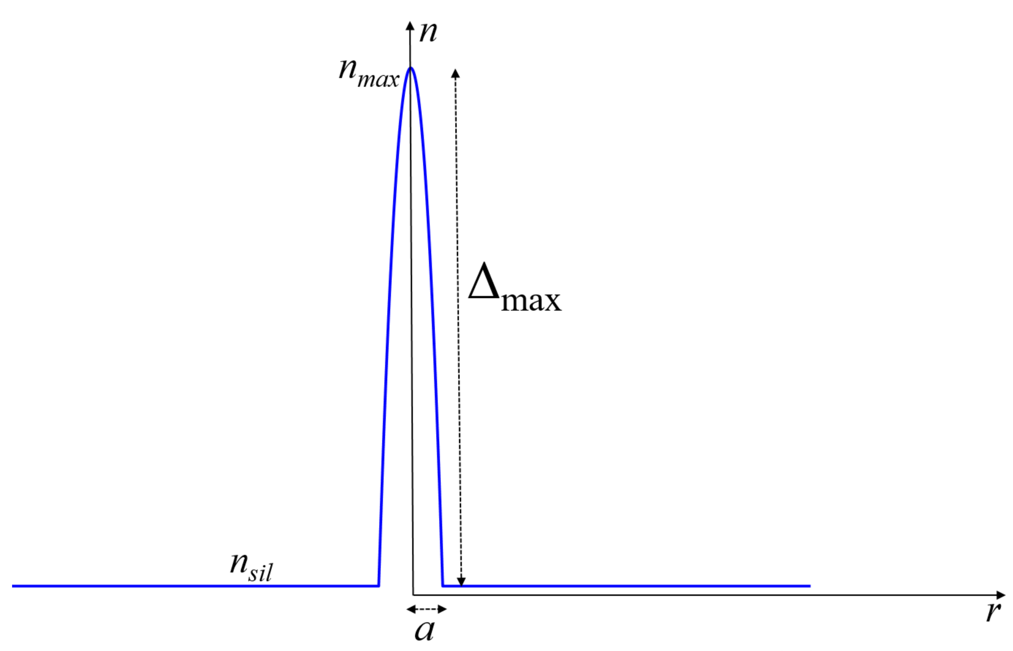

Figure 1. Graded index fiber profile $n(r)$

COMPUTATIONAL METHODS: RSL is inversely proportional to λ^4 , where λ is the light wavelength. Also RSL is directly proportional to light power $P(r)$ and Rayleigh scattering coefficient (RSC) $A(r)$ [1]. Hereby, RSL in the fibre core is given as,

$$\alpha_R = \frac{1}{\lambda^4}\int_0^a A(r)P(r)rdr \Big/ \int_0^a P(r)rdr$$

RSC of GeO_2-doped silica glass is given by [2],

$$A(r) = A_0(1 + 44|\Delta(r)|)$$

where, A_0 = 0.8 dB/km.µm^4 is the RSC of pure silica glass and Δ is the relative refractive index given as,

$$\Delta(r) = \left(n(r)^2 - n_{sil}^2\right)/\left(2n(r)^2\right)$$

where, the refractive index profile of a graded-index fiber is given by,

$$n(r) = n_{max}\sqrt{1 - \Delta_{max}\left(\frac{r}{a}\right)^\alpha}$$

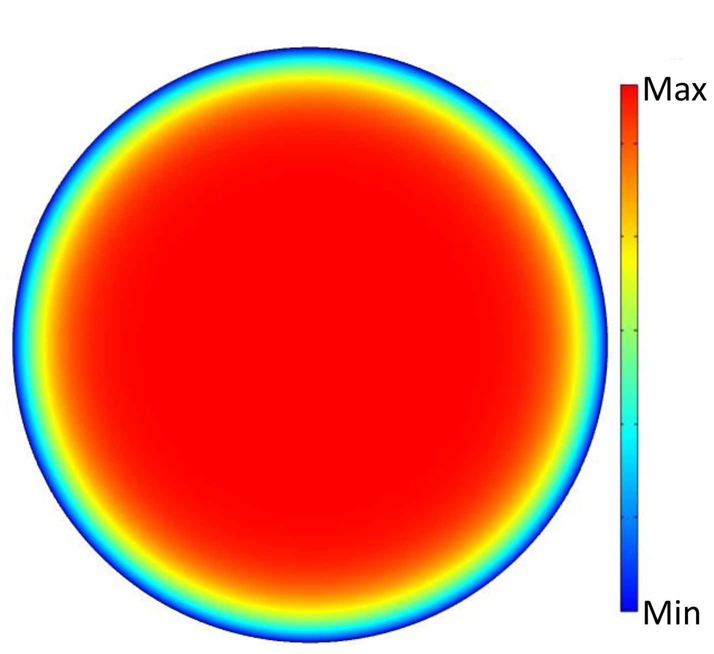

Figure 2. Surface plot of RSC $A(r)$ in the fiber core with the refractive index profile shown in Figure 1

After defining the refractive index profile and hence, the RSC, we solve the wave equations using COMSOL Multiphysics® Wave Optics module. This gives us the light power profile $P(r)$.

RESULTS: Figure 3 shows the variation in RSL as a function of grading parameter α for different values of Δ_{max}, keeping a = 4 µm. The figure shows that as GeO2 concentration increases (which can be through two ways: increase α and/or increase Δ_{max}), the RSL increases which supports the fact that increasing dopant concentration increases the number of scattering centers resulting in larger scatterings. Similarly follows the explanations for figure 4 and 5.

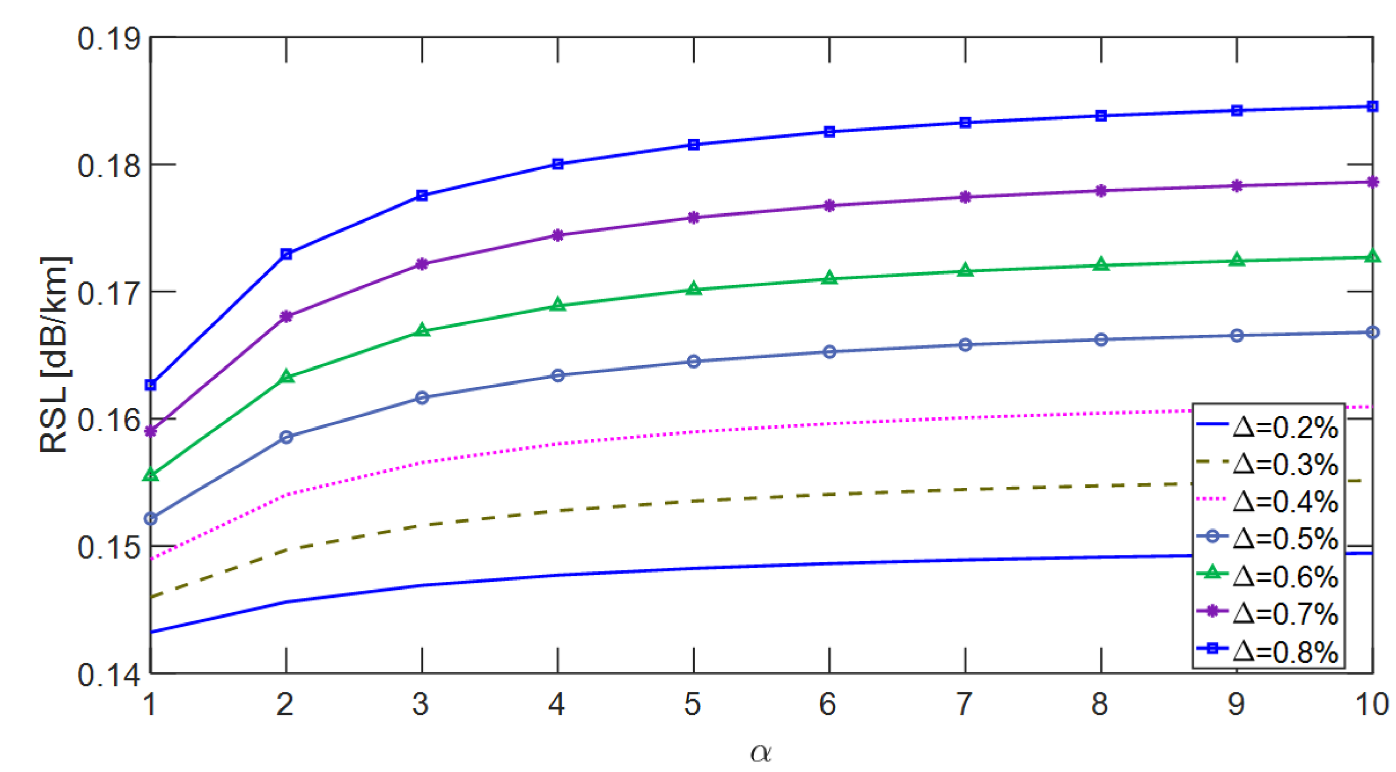

Figure 3. RSL in a graded-index fiber as a function of α for different values of Δ_{max}

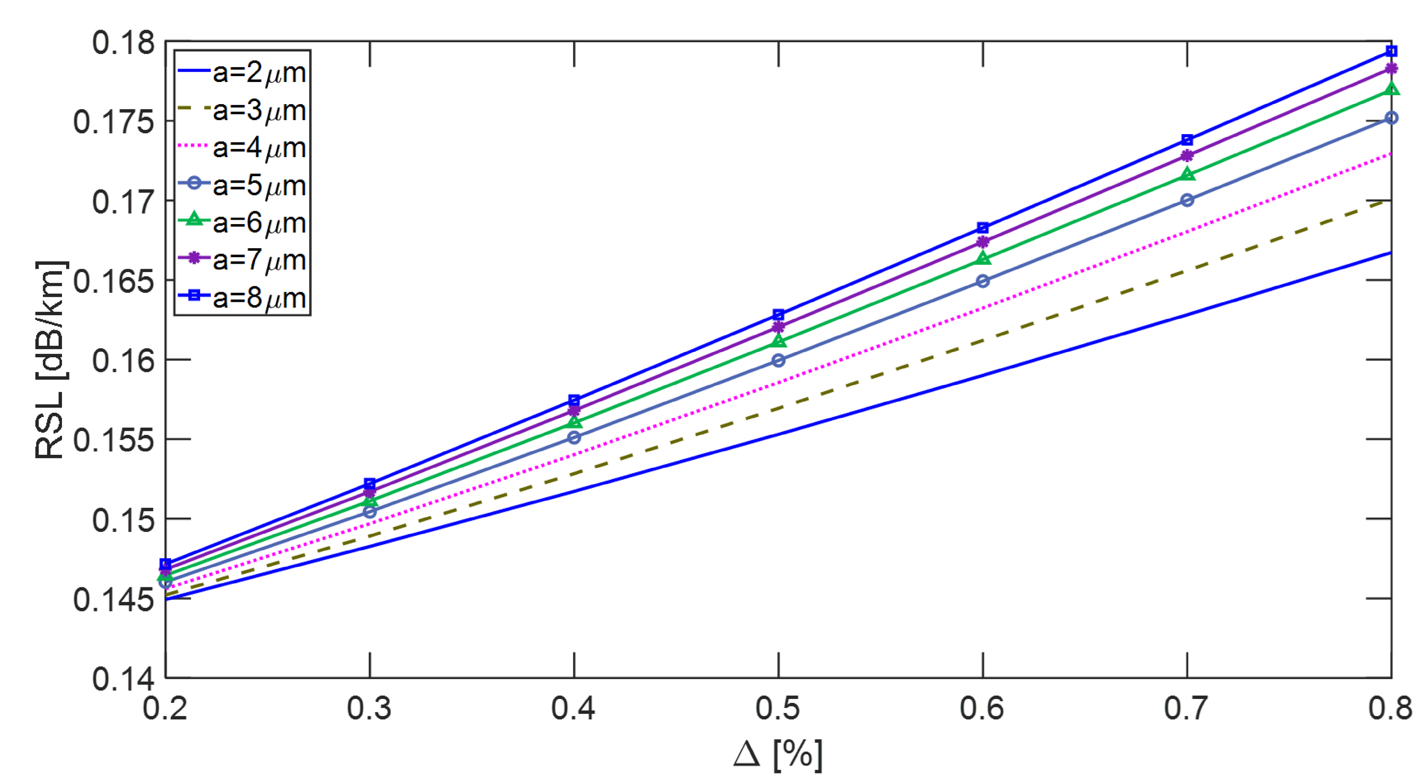

Figure 4. RSL in a graded-index fiber as a function of Δ for different values of core radius

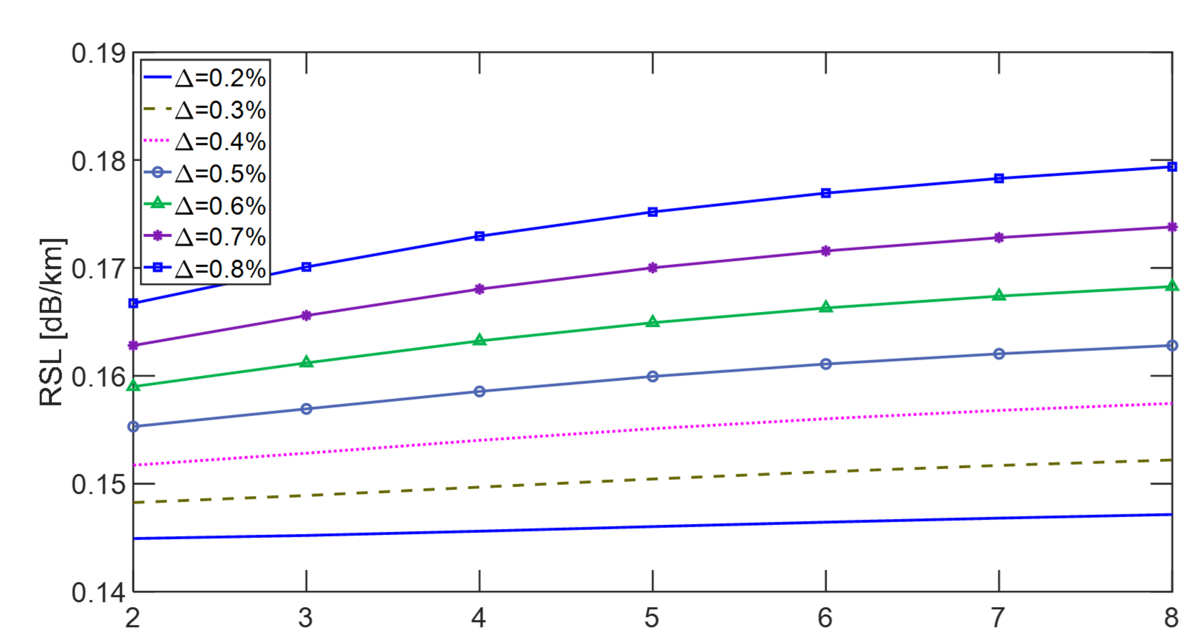

Figure 5. RSL in a graded-index fiber as a function of core radius for different values of Δ

CONCLUSIONS: In this work, we have presented a COMSOL Multiphysics® model to calculate RSL of arbitrary profile fiber which can be useful in predicting fiber attenuation from a designer's perspective.

REFERENCES:

1. M. Ohashi *et. al.*, "Optical loss property of silica-based single-mode fibers," *J. Lightw. Technol.*, 10, pp. 539 – 543 (1992)
2. W. Zhi *et. al.*, "Loss properties due to Rayleigh scattering in different types of fiber," *Opt. Exp.*, 11, pp. 39 – 47 (2003)