Field Guide to

Lasers

Rüdiger Paschotta

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John E. Greivenkamp, Series Editor

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Within the nearly five decades since the invention of the laser, a wide range of laser devices has been developed. The primary objectives of this *Field Guide* are to provide an overview of all essential lasers types and their key properties and to give an introduction into the most important physical and technological aspects of lasers. In addition to the basic principles, such as stimulated emission and the properties of optical resonators, this *Field Guide* discusses many practical issues, including the variety of important laser crystal properties, the impact of thermal effects on laser performance, the methods of wavelength tuning and pulse generation, and laser noise. Practitioners may also gain valuable insight from remarks on laser safety (emphasizing real-life issues rather than formal rules and classifications) and obtain new ideas about how to make the laser development process more efficient. Therefore, this *Field Guide* can be useful for researchers as well as engineers using or developing laser sources.

I am greatly indebted to my wife, who strongly supported the creation of this *Field Guide*, mainly by improving the majority of the figures.

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Table of Contents

A	area (e.g., the cross section of a laser beam)
B	brightness (radiance) of a laser beam
c	velocity of light in a vacuum
E	electric field strength
E_{sat}	saturation energy (e.g., of a laser medium)
f	focal length (e.g., of a thermal lens)
f_{ro}	relaxation oscillation frequency
F_{p}	fluence (energy per area) of a pulse
F_{sat}	saturation fluence (e.g., of a laser medium)
g	gain coefficient
g_0	small-signal gain coefficient or initial gain
G	power amplification factor (= $\exp(g)$)
h	Planck's constant
I	optical intensity (power per unit area)
I_{sat}	saturation intensity (e.g., of a laser medium)
k	wave number (= $2\pi / \lambda$)
l	loss coefficient (e.g., for round-trip losses of a resonator)
L	length (e.g., of a laser medium)
M^2	beam quality factor
n	refractive index
N_2	number density of ions in energy level 2
NA	numerical aperture
P	optical power (e.g., of a laser beam)
r	radial position (= distance from beam axis)
R	radius of curvature (e.g., of wavefronts)
T_{rt}	round-trip time of a resonator
T_{oc}	output coupler transmission
w	beam radius
w_0	beam radius at the beam waist
z	position coordinate along a laser beam
z_{R}	Rayleigh length of a laser beam

α	linewidth enhancement factor
φ	optical phase or azimuthal angle
θ	divergence angle
κ	thermal conductivity
λ	wavelength
ν	optical frequency
$\Delta\nu$	optical bandwidth
σ_{abs}	absorption cross section
σ_{em}	emission cross section
τ_2	upper-state lifetime