

Field Guide to

Spectroscopy

David W. Ball

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Field Guide to Spectroscopy

Of all the *Field Guides* published to date, this one may stand out due to its relatively broad topic: the field of spectroscopy. Indeed, entire field guides can be written on what is covered here in one or two pages (witness the two pages on polarization here versus an entire *Field Guide* devoted to that topic published previously). Whatever limitations this may impart on this volume, I accept them and expect that the reader will understand them, too.

This material is derived from several sources, including my own training in infrared and circular dichroism spectroscopy from Rice University and the Lawrence Berkeley Laboratory; from courses I have taught in spectroscopy at Cleveland State University; and from personal research I conducted in the course of authoring “The Baseline” column in *Spectroscopy* magazine since 1994. Writing is a form of self-education, and I have been blessed with fast (though not always accurate) typing skills with which I can benefit by increased writing and, as a result, learning.

Thanks go to my colleague, John F. Turner II, for his review of the initial Table of Contents. I would also like to thank reviewers Brad Stone of San Diego State University and Vidi Saptari of MKS Instruments, Inc., for their thoughtful comments on the manuscript, and John E. Greivencamp of the University of Arizona, series editor, for leadership in the *Field Guides* series. Thanks are also due to Dr. Koji Masutani of Micro Science Inc. for corrections made while preparing the Japanese translation of this book.

This *Field Guide* is dedicated to my family: my wife, Gail, and my sons, Stuart and Casey.

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Glossary

<i>a</i>	Absorptivity
<i>a</i>	Hyperfine coupling constant
<i>a</i>	Width
<i>A</i>	Ammeter
<i>A</i>	Einstein coefficient of spontaneous emission
<i>A</i> (λ)	Absorbance at some wavelength λ
ATR	Attenuated total reflection
<i>b</i>	Path length
<i>B</i>	Beamsplitter
<i>B</i>	Magnetic flux strength
<i>B</i>	Einstein coefficient of stimulated absorption
<i>B</i>	Rotational constant
B	Magnetic flux density
BE	Binding energy of electron
<i>c</i>	Concentration
<i>c</i>	Speed of light in vacuum
<i>c'</i>	Speed of light in transparent medium
<i>c_n</i>	Linear combination expansion coefficient
<i>C</i>	Compensator
CCD	Charge coupled device
CD	Circular dichroism
CID	Charge injection device
<i>d</i>	Distance between grating grooves
<i>D_a</i>	Angular dispersion
<i>D_l</i>	Linear dispersion
D1, etc.	Dynode 1, etc.
<i>e</i>	Charge on the electron
E	Electric field
<i>E</i>	Energy
ΔE	Change in energy
$\langle E \rangle$	Average energy
EPR	Electron paramagnetic resonance
ESR	Electron spin resonance
<i>f</i>	Focal length
<i>f</i> (<i>t</i>)	Time-dependent function
<i>F</i>	Focal point
<i>F</i>	Force

Glossary

$F(\omega), F(\nu)$	Fourier transform
$F(\nu)$	Lineshape function
FID	Free induction decay
FIR	Far infrared
FT	Fourier transform
FTIR	Fourier transform infrared spectroscopy
FT-NMR	Fourier transform nuclear magnetic resonance spectroscopy
FWHM	Full width at half maximum
g_e	Electron g factor
g_J	Landé g factor
g_N	Nuclear g factor
G	Grating
h	Planck's constant
\hbar	Planck's constant divided by 2π
HCL	Hollow-cathode lamp
H	Magnetic field
\hat{H}	Hamiltonian operator for energy
$H(\alpha^{1/2}x)$	Hermite polynomial
i	The square root of -1
I	Intensity
I	Moment of inertia
I	Nuclear spin quantum number
I_a	Intensity of absorbed light
I_p	Intensity of p-polarized light
I_r	Intensity of reflected light
I_s	Intensity of s-polarized light
I_t	Intensity of transmitted light
ICP	Inductively coupled plasma
IR	Infrared
J	Free current density
J	Rotational quantum number
J	Total (spin + orbital) angular momentum
ΔJ	Change in rotational quantum number
k	Boltzmann's constant
k	Force constant
ℓ	Length

Glossary

ℓ	(3D) Angular momentum quantum number
LED	Light-emitting diode
L, L_{tot}	Total angular momentum
L_z	Z-component angular momentum
\hat{L}_z	Z-component angular momentum operator
\hat{L}_{tot}^2	Squared total angular momentum operator
m	Mass
m	Order of refraction
m_e	Mass of the electron
m_ℓ	(2D) Angular momentum quantum number
m_s	Z-component of spin angular momentum quantum number
M	Mirror
M	Transition moment
M_I	Z-component of nuclear spin angular momentum
M_J	Z-component of total angular momentum
n	Index of refraction
n	Quantum number (principal)
Δn	Change in quantum number
NIR	Near infrared light
NMR	Nuclear magnetic resonance
$\langle O \rangle$	Average value of property O
p	Momentum, linear
\hat{p}	Momentum operator, linear
$P(t)$	Probability, time-based
PDA	Photodiode array
PMT	Photomultiplier tube
QM	Quantum mechanics
r	Distance
R	Radius of curvature
R	Resolution
R_d	Reciprocal linear dispersion
S	Source

Glossary

S	Spin angular momentum quantum number
$2S+1$	Multiplicity
S1, S2	Slits
SNR	Signal-to-noise ratio
t	Time
T	Temperature, absolute
T	Transmittance
$\%T$	Percent transmittance
TDSE	Time-dependent Schrödinger equation
TISE	Time-independent Schrödinger equation
UPS	Ultraviolet photoelectron spectroscopy
UV	Ultraviolet light
UVA	Ultraviolet A
UVB	Ultraviolet B
v	Velocity
V	Verdet constant
V	Potential energy
\hat{V}	Potential energy operator
x	Position
\hat{x}	Position operator
XPS	X-ray photoelectron spectroscopy
α	Angle of incoming light
β	Angle of preferential refraction
γ	Blaze angle
γ	Magnetogyric ratio
δ	Chemical shift parameter
Γ	Irreducible representation of point group
ϵ_0	Permittivity of free space
$\epsilon(\lambda)$	Molar extinction coefficient
θ	Angle of dispersion
θ	Angle of rotation
θ_c	Critical angle
θ, θ_i	Angle of incidence
θ_r	Angle of reflection
λ	Wavelength of light
λ_{\max}	Maximum wavelength
$\Delta\lambda$	Wavelength range

Glossary

μ	Magnetic permeability
μ	Reduced mass
μ_0	Permeability of free space
μ_B	Bohr magneton
μ_N	Nuclear magneton
$\hat{\mu}$	Dipole moment operator
ν	Frequency of light
ν	Larmor frequency
$\tilde{\nu}$	Wavenumber of light
ρ	Free electric charge density
$\rho, \rho(\nu)$	Radiation density
σ	Screening constant
ϕ	Angle
ϕ	Angle of refraction
ϕ	Work function
ϕ, Φ	Trial wave function
Ψ	Wavefunction
Ψ^*	Wavefunction, complex-conjugated
ω	Angular frequency