

Springer Series in

**Optical Sciences**

R. H. Kingston

**Detection of  
Optical and Infrared  
Radiation**



Springer-Verlag Berlin Heidelberg New York

116/2444 INSTITUT  
FÜR METEOROLOGIE U. KLIMATOLOGIE  
UNIVERSITÄT HANNOVER  
HERRENHAUSER STR. 2 • 3000 HANNOVER 21

R. H. Kingston

Detection of  
Optical and Infrared  
Radiation

With 39 Figures

Springer-Verlag Berlin Heidelberg New York 1978

# Contents

<b>1. Thermal Radiation and Electromagnetic Modes</b> . . . . .	1
1.1 The Nature of the Thermal Radiation Field . . . . .	1
1.2 Derivation of Planck's Radiation Law . . . . .	2
1.3 General Properties of Blackbody Radiation . . . . .	5
1.4 A Plausibility Test of the Planck Distribution . . . . .	7
1.5 Numerical Constants and Typical Values . . . . .	8
Problems . . . . .	9
<b>2. The Ideal Photon Detector</b> . . . . .	10
2.1 Event Probability and the Poisson Distribution . . . . .	10
2.2 Noise in the Detection Process . . . . .	11
2.3 Signal-Noise-Limited Detection . . . . .	14
2.4 Background-Noise-Limited Detection . . . . .	15
2.5 $NEP$ and $D^*$ in the Presence of Thermal Background . . . . .	16
2.6 An Illustrative Example of Background-Limited Detection . . . . .	17
2.7 $D^*$ for an Ideal Detector . . . . .	20
Problems . . . . .	23
<b>3. Coherent or Heterodyne Detection</b> . . . . .	24
3.1 Heterodyne Conversion and Noise . . . . .	24
3.2 The Antenna Theorem . . . . .	28
3.3 The Mixing Theorem . . . . .	31
3.4 A Rederivation of Planck's Law . . . . .	35
Problems . . . . .	37
<b>4. Amplifier Noise and Its Effect on Detector Performance</b> . . . . .	39
4.1 Amplifier Noise in Incoherent Detection . . . . .	40
4.2 Amplifier Noise in Coherent or Heterodyne Detection . . . . .	41
Problems . . . . .	42
<b>5. Vacuum Photodetectors</b> . . . . .	43
5.1 Vacuum Photodiodes . . . . .	43
5.2 Photomultipliers . . . . .	47
Problems . . . . .	50

<b>6. Noise and Efficiency of Semiconductor Devices</b>	52
6.1 Photoconductors	52
6.2 Semiconductor Photodiodes	64
6.3 Avalanche Photodiodes	76
Problems	81
<b>7. Thermal Detection</b>	83
7.1 Fluctuations of the Radiation Field	83
7.2 Sensitivity of the Ideal Thermal Detector	89
7.3 Bolometers	93
7.4 The Pyroelectric Detector	95
7.5 Heterodyne Detection with Thermal Detectors	98
Problems	100
<b>8. Laser Preamplification</b>	101
Problems	104
<b>9. The Effects of Atmospheric Turbulence</b>	105
9.1 Heterodyne-Detection Limitations	105
9.2 Incoherent-Detection Limitations	108
Problems	109
<b>10. Detection Statistics</b>	110
10.1 Statistics of Target Backscatter	110
10.2 Detection and False-Alarm Probability for the Incoherent Case	113
10.3 The Coherent Case	116
10.4 Photoelectron-Counting Case	117
Problems	120
<b>11. Selected Applications</b>	121
11.1 Radar	121
11.2 Radiometry and Spectroscopy	125
11.3 Stellar Interferometry	131
11.4 Intensity Interferometry	134
Problems	136
References	137
Subject Index	139