
CONTENTS

Preface	xiii
Autobiographical Notes	xv
Section 1. Methods for Spectroscopy with Coherent Radiation and Atomic Clocks	1
<i>Paper 1.1</i>	3
“The Magnetic Moments of the Proton and the Deuteron: The Radiofrequency Spectrum of H ₂ in Various Magnetic Fields,” J. M. B. Kellogg, I. I. Rabi, N. F. Ramsey and J. R. Zacharias, <i>Phys. Rev.</i> 56 , 728–742 (1939)	4
<i>Paper 1.2</i>	20
“A Molecular Beam Resonance Method with Separated Oscillating Fields,” N. F. Ramsey, <i>Phys. Rev.</i> 78 , 695–699 (1950)	21
<i>Paper 1.3</i>	26
“Phase Shifts in the Molecular Beam Method of Separated Oscillating Fields,” N. F. Ramsey and H. B. Silsbee, <i>Phys. Rev.</i> 84 , 506–507 (1951)	27
<i>Paper 1.4</i>	29
“Nuclear Audiofrequency Spectroscopy by Resonant Heating of the Nuclear Spin System,” N. F. Ramsey and R. V. Pound, <i>Phys. Rev.</i> 81 , 278–279 (1951)	30
<i>Paper 1.5</i>	32
“Use of Rotating Coordinates in Magnetic Resonance Problems,” I. I. Rabi, N. F. Ramsey and J. Schwinger, <i>Rev. Mod. Phys.</i> 26 , 167–171 (1954)	33
<i>Paper 1.6</i>	38
“Resonance Transitions Induced by Perturbations at Two or More Different Frequencies,” N. F. Ramsey, <i>Phys. Rev.</i> 100 , 1191–1194 (1955)	39
<i>Paper 1.7</i>	43
“Resonance Experiments in Successive Oscillatory Fields,” N. F. Ramsey, <i>Rev. Sci. Instrum.</i> 28 , 57 (1957)	44

Paper 1.8	45
“Molecular Beam Resonances in Oscillatory Fields of Nonuniform Amplitudes and Phases,” N. F. Ramsey, <i>Phys. Rev.</i> 109 , 822–825 (1958)	46
Paper 1.9	50
“Shapes of Molecular Beam Resonances,” Norman F. Ramsey, <i>Recent Research in Molecular Beams</i> A29 , 107–119, Academic Press, New York (1959)	51
Paper 1.10	64
“Atomic Hydrogen Maser,” H. M. Goldenberg, D. Kleppner and N. F. Ramsey, <i>Phys. Rev. Lett.</i> 8 , 361–362 (1960)	65
Paper 1.11	67
“Theory of the Hydrogen Maser,” D. Kleppner, H. M. Goldenberg and N. F. Ramsey, <i>Phys. Rev.</i> 126 , 603–615 (1962)	68
Paper 1.12	81
“Large Storage Box Hydrogen Maser,” E. E. Uzgiris and N. F. Ramsey, <i>IEEE J. Quantum Electronics</i> QE-4 , 563–568 (1968)	82
Paper 1.13	88
“Atomic Deuterium Maser,” D. J. Wineland and N. F. Ramsey, <i>Phys. Rev.</i> A5 , 821–837 (1972)	89
Paper 1.14	106
“Precise Measurement of Time,” N. F. Ramsey, <i>American Scientist</i> 76 , 42–49 (1988)	107
Paper 1.15	115
“Experiments With Separated Oscillatory Fields and Hydrogen Masers” (Nobel Lecture), N. F. Ramsey, <i>Les Prix Nobel</i> (1989, The Nobel Foundation) and <i>Rev. Mod. Phys.</i> 62 , 541–552 (1990)	116
Paper 1.16	128
“Successive Oscillatory Fields at Radio to Optical Frequencies,” N. F. Ramsey, <i>Appl. Phys.</i> B60 , 85–88 (1995)	129

Section 2. Radiofrequency and Microwave Spectroscopy Experiments	133
Paper 2.1	135
“An Electrical Quadrupole Moment of the Deuteron: The Radiofrequency Spectra of HD and D ₂ Molecules in a Magnetic Field,” J. M. B. Kellogg, I. I. Rabi, N. F. Ramsey and J. R. Zacharias, <i>Phys. Rev.</i> 57 , 677–695 (1940)	136
Paper 2.2	155
“The Rotational Magnetic Moments of H ₂ , D ₂ , and HD Molecules,” N. F. Ramsey, <i>Phys. Rev.</i> 58 , 226–236 (1940)	156
Paper 2.3	167
“Measurements of Nuclear Quadrupole Moment Interactions,” W. A. Nierenberg, N. F. Ramsey and S. B. Brody, <i>Phys. Rev.</i> 70 , 773–775 (1946)	168
Paper 2.4	170
“Nuclear Radiofrequency Spectra of H ₂ and D ₂ in High and Low Magnetic Fields,” H. G. Kolsky, T. E. Phipps, H. B. Silsbee and N. F. Ramsey, <i>Phys. Rev.</i> 87 , 395–403 (1952)	171
Paper 2.5	180
“Radiofrequency Spectra of Hydrogen Deuteride in Strong Magnetic Fields,” W. E. Quinn, J. M. Baker, J. T. LaTourrette and N. F. Ramsey, <i>Phys. Rev.</i> 112 , 1929–1940 (1958)	181
Paper 2.6	193
“Nuclear Interactions in Deuterium Fluoride,” H. M. Nelson, J. A. Leavitt, M. R. Baker and N. F. Ramsey, <i>Phys. Rev.</i> 122 , 856–859 (1961)	194
Paper 2.7	198
“Rotational Magnetic Moments of Lithium Hydride and Deuteride,” T. R. Lawrence, C. H. Anderson and N. F. Ramsey, <i>Phys. Rev.</i> 130 , 1865–1870 (1963)	199
Paper 2.8	205
“Hyperfine Separation of Ground-State Atomic Hydrogen,” S. B. Crampton, D. Kleppner and N. F. Ramsey, <i>Phys. Rev. Lett.</i> 11 , 338–340 (1963)	206

Paper 2.9	209
“Stark Shift of the Hydrogen Hyperfine Separation,” E. N. Fortson, D. Kleppner and N. F. Ramsey, <i>Phys. Rev. Lett.</i> 13 , 22–23 (1964)	210
Paper 2.10	212
“Rotational Magnetic Moments,” J. W. Cederberg, C. H. Anderson and N. F. Ramsey, <i>Phys. Rev.</i> 136 , A960–A961 (1964)	213
Paper 2.11	215
“Absolute Value of the Proton g Factor,” T. Myint, D. Kleppner, N. F. Ramsey and H. G. Robinson, <i>Phys. Rev. Lett.</i> 17 , 405–407 (1966)	216
Paper 2.12	219
“Hyperfine Separation of Tritium,” B. S. Mathur, S. B. Crampton, D. Kleppner and N. F. Ramsey, <i>Phys. Rev.</i> 158 , 14–17 (1967)	220
Paper 2.13	224
“Measurements of the Hydrogen-Deuterium Atomic Magnetic Moment Ratio and of the Deuterium Hyperfine Frequency,” D. J. Larson, P. A. Valberg and N. F. Ramsey, <i>Phys. Rev. Lett.</i> 23 , 1369–1371 (1969)	225
Paper 2.14	229
“Direct Observation of Ortho–Para Transitions in Methane,” I. Ozier, P. N. Yi, A. Khosla and N. F. Ramsey, <i>Phys. Rev. Lett.</i> 24 , 642–646 (1970)	230
Paper 2.15	235
“Hyperfine Structure of $^7\text{Li}^{79,81}\text{Br}$ by Molecular-Beam Electric Resonance,” R. C. Hilborn, T. F. Gallagher, Jr. and N. F. Ramsey, <i>J. Chem. Phys.</i> 56 , 855–861 (1972)	236
Paper 2.16	243
“Molecular-Beam Magnetic-Resonance Measurements of the Anisotropies of the Electric Polarizabilities of H_2 and D_2 ,” K. B. MacAdam and N. F. Ramsey, <i>Phys. Rev.</i> A6 , 898–906 (1972)	244
Paper 2.17	253
“The Molecular Zeeman and Hyperfine Spectra of LiH and LiD by Molecular Beam High Resolution Electric Resonance,” R. R. Freeman, A. R. Jacobson, D. W. Johnson and N. F. Ramsey, <i>J. Chem. Phys.</i> 63 , 2597–2602 (1975)	254

Paper 2.18	260
“Rotational Magnetic Moment Spectra of a Series of Tetrahedral Molecules,” I. Ozier, S. S. Lee and N. F. Ramsey, <i>J. Chem. Phys.</i> 65 , 3985–3993 (1976)	261
Paper 2.19	270
“Measurement of the Neutron Magnetic Moment,” G. L. Green, N. F. Ramsey, W. Mampe, J. M. Pendlebury, K. Smith, W. B. Dress, P. D. Miller and P. Perrin, <i>Phys. Rev. D</i> 20 , 2139–2153 (1979)	271
Section 3. Parity, Time Reversal Symmetry and Electric Dipole Moments	287
Paper 3.1	289
“On the Possibility of Electric Dipole Moments for Elementary Particles and Nuclei,” E. M. Purcell and N. F. Ramsey, <i>Phys. Rev.</i> 78 , 807 (1950)	290
Paper 3.2	291
“Experimental Limit to the Electric Dipole Moment of the Neutron,” J. H. Smith, E. M. Purcell and N. F. Ramsey, <i>Phys. Rev.</i> 108 , 120–122 (1957)	292
Paper 3.3	295
“A Search for the Electric Dipole Moment of the Neutron,” K. F. Smith, J. M. Pendlebury, K. Green, B. R. Heckel, N. F. Ramsey, S. Lamoreaux, W. Mampe, <i>et al.</i> , <i>Phys. Lett.</i> B234 , 191–196 (1990)	296
Paper 3.4	302
“Time Reversal, Charge Conjugation, Magnetic Pole Conjugation, and Parity,” N. F. Ramsey, <i>Phys. Rev.</i> 109 , 225 (1958)	303
Paper 3.5	304
“First Measurement of Parity-Nonconserving Neutron-Spin Rotation: The Tin Isotopes,” M. Forte, B. R. Heckel, N. F. Ramsey, K. Green, G. L. Greene, J. Byrne and J. M. Pendlebury, <i>Phys. Rev. Lett.</i> 45 , 2088–2092 (1980)	305
Paper 3.6	310
“Search for <i>P</i> and <i>T</i> Violations in the Hyperfine Structure of Thallium Fluoride,” D. A. Wilkening, N. F. Ramsey and D. J. Larson, <i>Phys. Rev.</i> A29 , 425–438 (1984)	311

Paper 3.7	325
“Electric Dipole Tests of Time Reversal Symmetry,” N. F. Ramsey, <i>At. Phys.</i> 14 , 3–17 (1995) (AIP Conf., Proc., 323)	326
 Section 4. Theories of Nuclear Magnetic Shielding and NMR Chemical Shifts	 341
Paper 4.1	343
“Magnetic Shielding of Nuclei in Molecules,” N. F. Ramsey, <i>Phys. Rev.</i> 78 , 699–703 (1950)	344
 Paper 4.2	 349
“Dependence of Magnetic Shielding of Nuclei upon Molecular Orientation,” N. F. Ramsey, <i>Phys. Rev.</i> 83 , 540–541 (1951)	350
 Paper 4.3	 352
“Temperature Dependent Magnetic Shielding in Ethyl Alcohol,” U. Liddel and N. F. Ramsey, <i>J. Chem. Phys.</i> 19 , 1608 (1951)	353
 Paper 4.4	 354
“Chemical Effects in Nuclear Magnetic Resonance and in Diamagnetic Susceptibility,” N. F. Ramsey, <i>Phys. Rev.</i> 86 , 243–246 (1952)	355
 Paper 4.5	 359
“Nuclear Magnetic Anti-shielding of Nuclei in Molecules: Magnetic Moments of F ¹⁹ , N ¹⁴ , and N ¹⁵ ,” M. R. Baker, C. H. Anderson and N. F. Ramsey, <i>Phys. Rev.</i> 133 , A1533–A1536 (1964)	360
 Section 5. Theories of Nuclear Interactions in Molecules	 365
 Paper 5.1	 367
“Theory of Molecular Hydrogen and Deuterium in Magnetic Fields,” N. F. Ramsey, <i>Phys. Rev.</i> 85 , 60–65 (1952)	368
 Paper 5.2	 374
“Vibrational and Centrifugal Effects on Nuclear Interactions and Rotational Moments in Molecules,” N. F. Ramsey, <i>Phys. Rev.</i> 87 , 1075–1079 (1952)	375

Paper 5.3	380
“Electron Distribution in Molecular Hydrogen,” N. F. Ramsey, <i>Science</i> 117 , 470 (1953)	381
Paper 5.4	382
“Spin Interactions of Accelerated Nuclei in Molecules,” N. F. Ramsey, <i>Phys. Rev.</i> 90 , 232–233 (1953)	383
Paper 5.5	385
“Interactions Between Nuclear Spins in Molecules,” N. F. Ramsey and E. M. Purcell, <i>Phys. Rev.</i> 85 , 143 (1952)	386
Section 6. General Principles and Theories	387
Paper 6.1	389
“Thermodynamics and Statistical Mechanics at Negative Absolute Temperatures,” N. F. Ramsey, <i>Phys. Rev.</i> 103 , 20–28 (1956)	390
Paper 6.2	399
“Significance of Potentials in Quantum Theory,” W. H. Furry and N. F. Ramsey, <i>Phys. Rev.</i> 118 , 623–626 (1960)	400
Paper 6.3	404
“The Tensor Force Between Two Protons at Long Range,” N. F. Ramsey, <i>Physica</i> 96A , 285–289 (1979)	405
Paper 6.4	410
“Quantum Mechanics and Precision Measurements,” N. F. Ramsey, <i>Physica Scripta</i> T59 , 26–28 (1995)	411
Paper 6.5	414
“Complementarity with Neutron Two-Path Interferences and Separated-Oscillatory-Field Resonances,” N. F. Ramsey, <i>Phys. Rev.</i> A48 , 80–82 (1993)	415