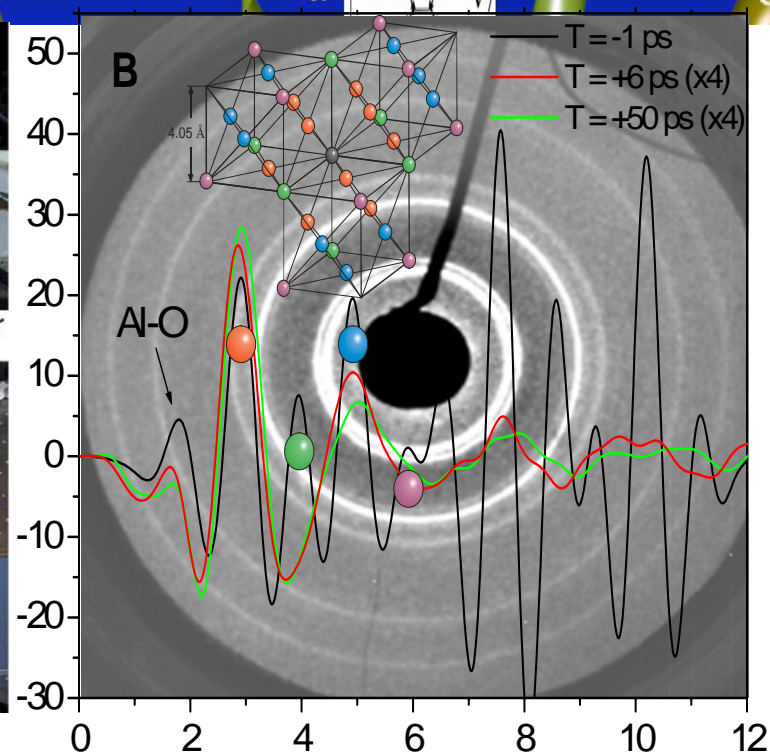
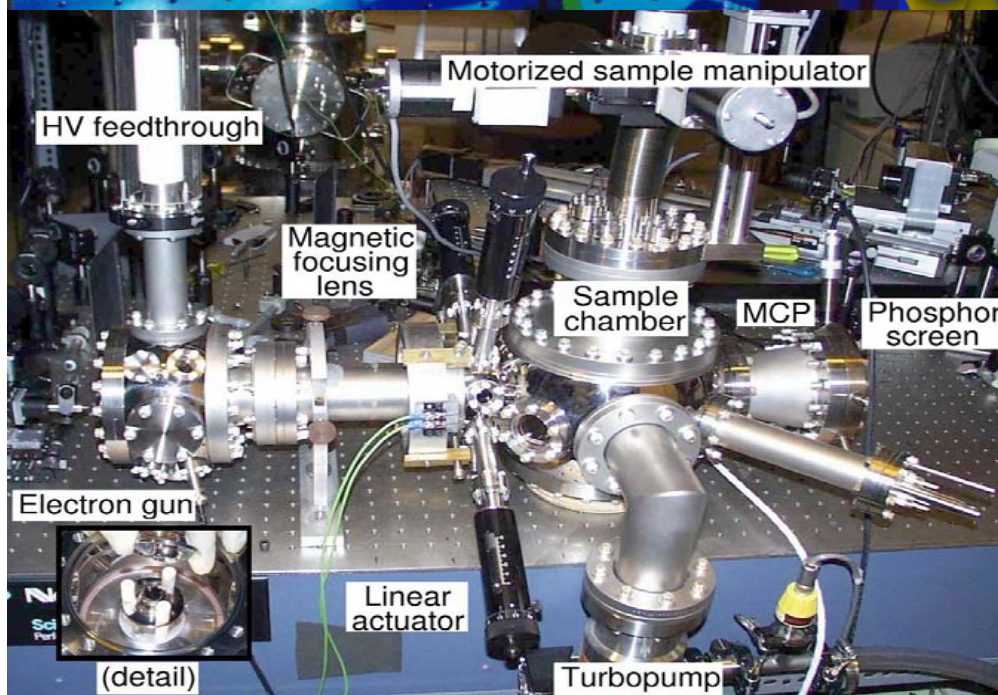
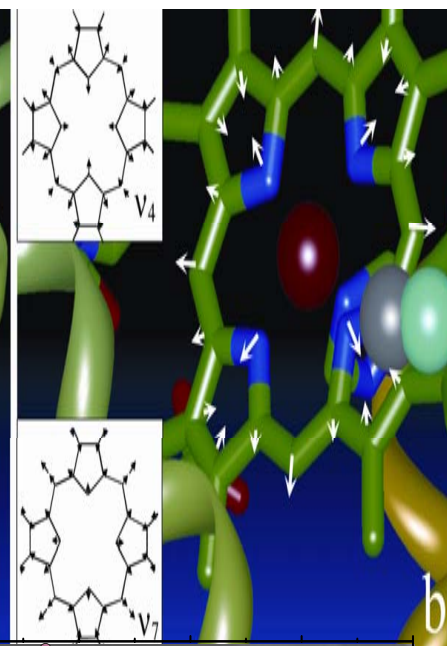
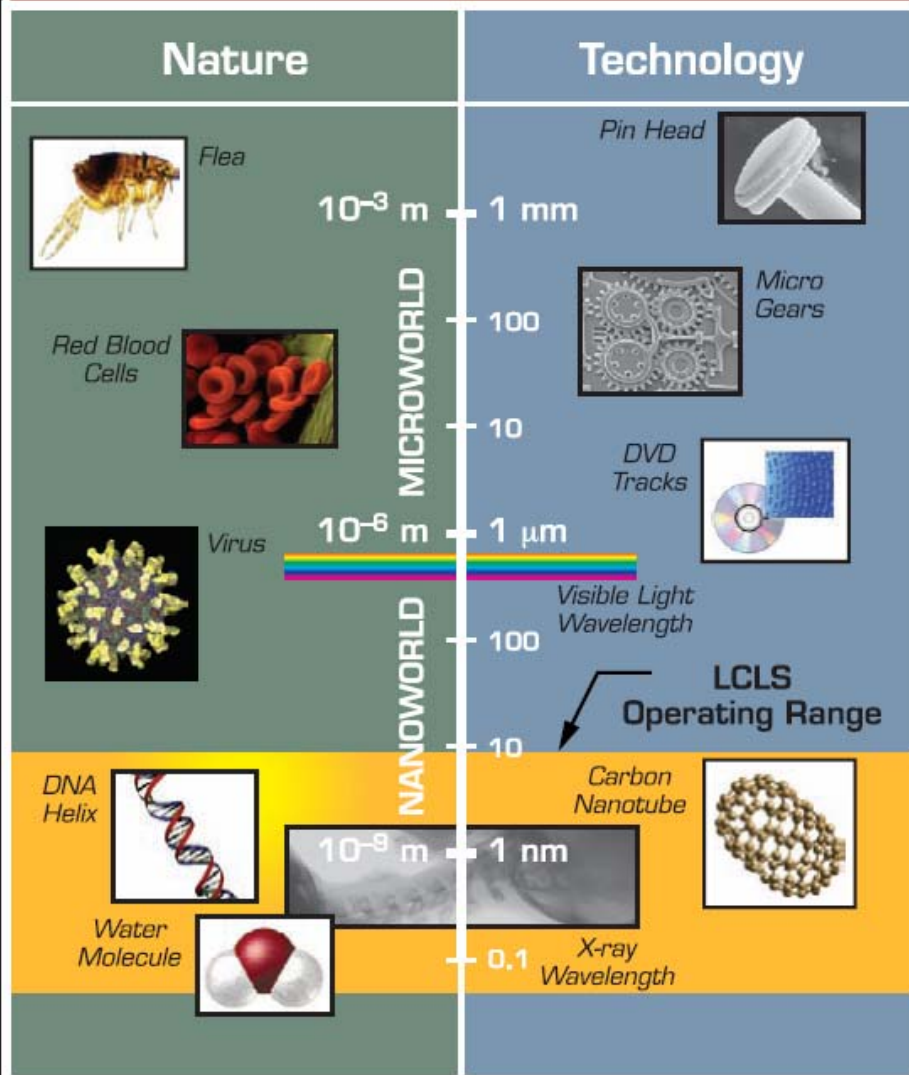


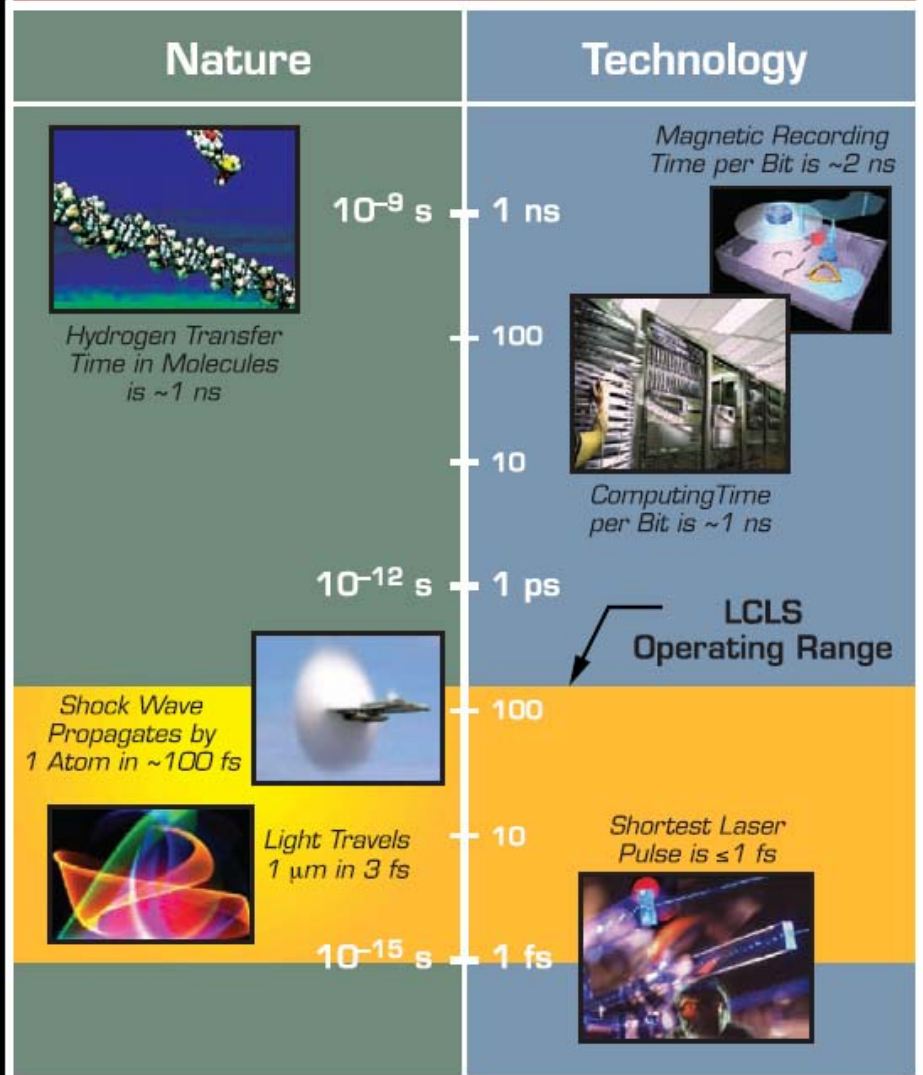
Uncovering the Secret Life of Molecules: Adventures in Physics and Chemistry



Ultra-Small



Ultra-Fast



Periodic Table of the Elements

1 IA	New Original																18 VIIIA
1 H Hydrogen 1.00794	2 He Helium 4.002602											13 Al Aluminum 26.981538	14 Si Silicon 28.0855	15 P Phosphorus 30.973761	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
2 Li Lithium 6.941	4 Be Beryllium 9.012182											5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
3 Na Sodium 22.989770	12 Mg Magnesium 24.3050	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII	10 VIII	11 IB	12 IIB	13 Al Aluminum 26.981538	14 Si Silicon 28.0855	15 P Phosphorus 30.973761	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
4 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955910	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938049	26 Fe Iron 55.8457	27 Co Cobalt 58.933200	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.409	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798
5 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90639	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.750	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.293
6 Cs Cesium 132.90545	56 Ba Barium 137.327	57 to 71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.078	79 Au Gold 196.96655	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98038	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
7 Fr Francium (223)	88 Ra Radium (226)	89 to 103	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (271)	111 Rg Roentgenium (272)	112 Uub Ununbium (285)	113 Uut Ununtrium (284)	114 Uuq Ununquadium (289)	115 Uup Ununpentium (288)	116 Uuh Ununhexium (292)	117 Ununseptium	118 Ununoctium

- Alkali metals
- Alkaline earth metals
- Transition metals
- Lanthanide series
- Actinide series
- Poor metals
- Nonmetals
- Noble gases
- C Solid
- Br Liquid
- H Gas
- Tc Synthetic

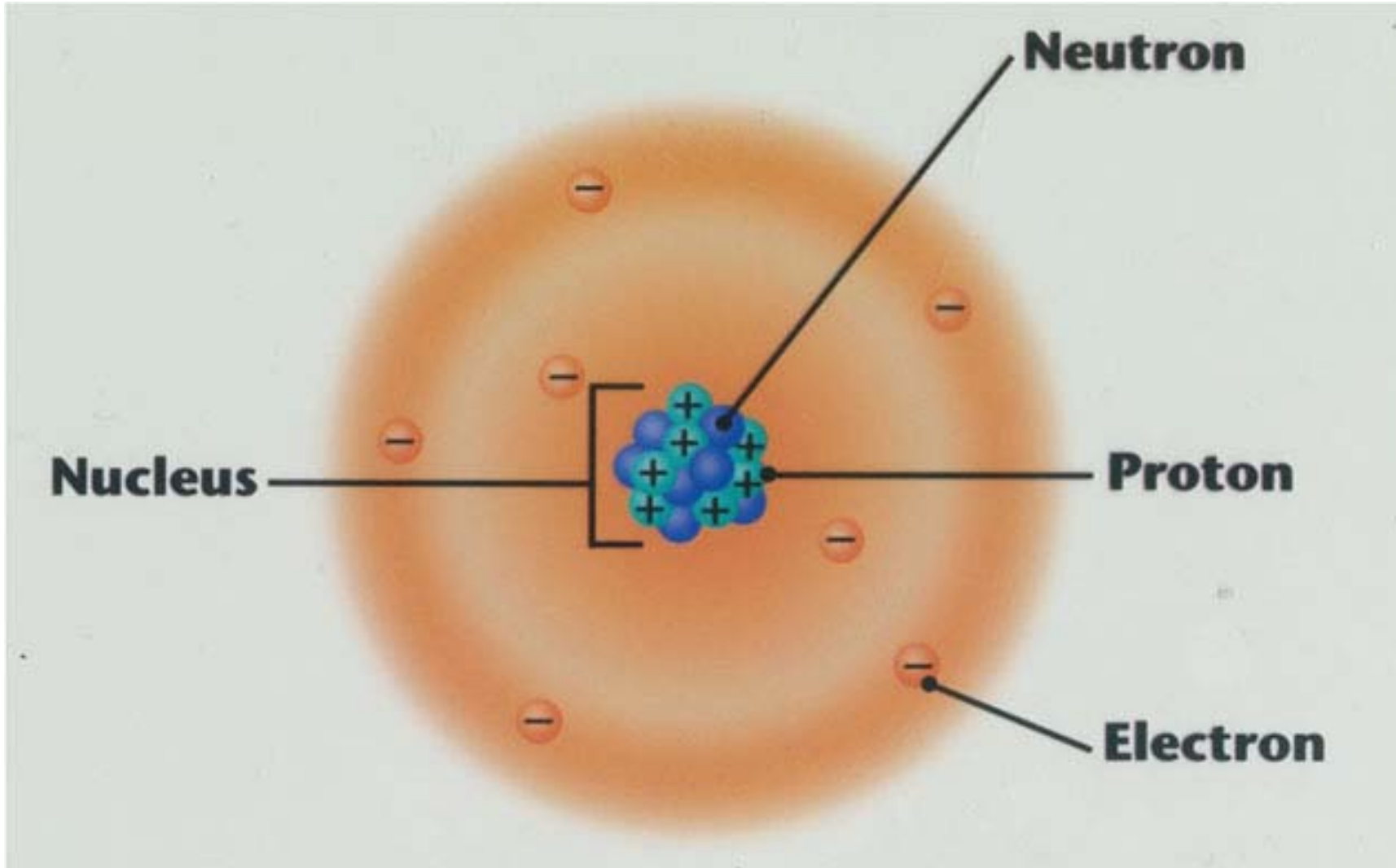
Atomic masses in parentheses are those of the most stable or common isotope.

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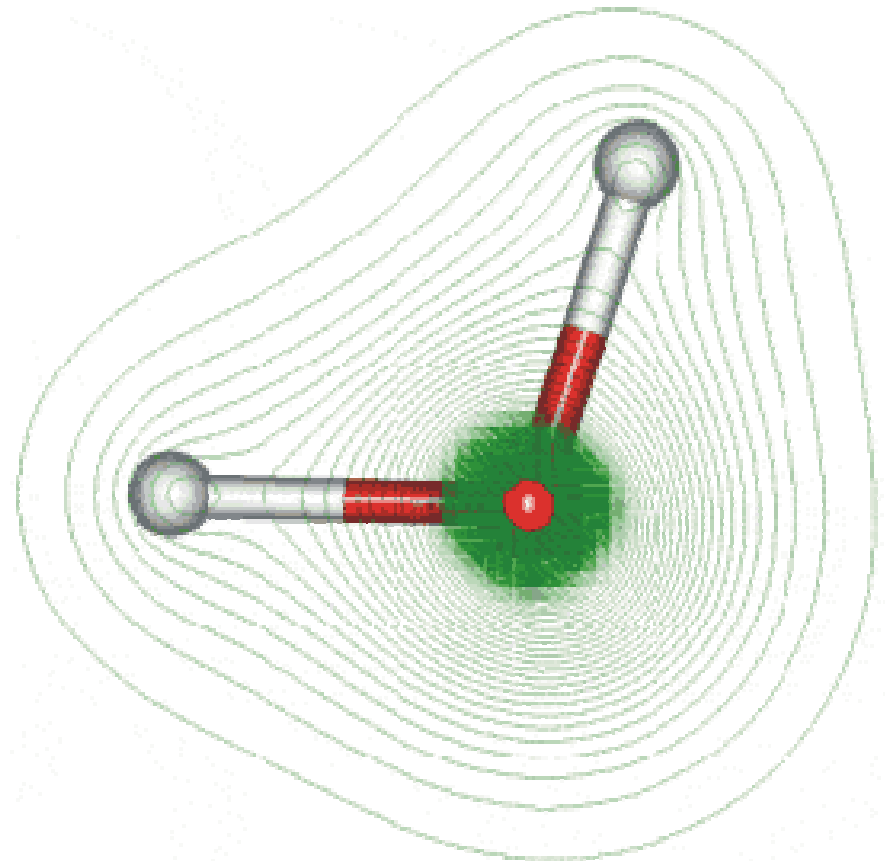
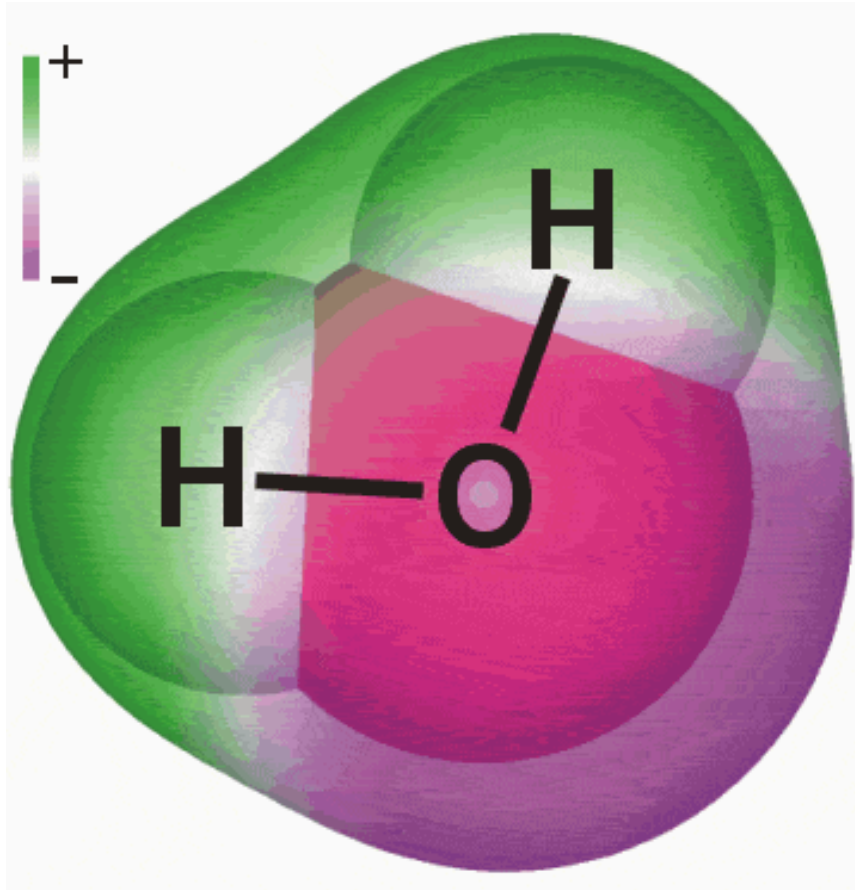
Note: The subgroup numbers 1-18 were adopted in 1984 by the International Union of Pure and Applied Chemistry. The names of elements 112-118 are the Latin equivalents of those numbers.

57 La Lanthanum 138.9055	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93032	68 Er Erbium 167.259	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
89 Ac Actinium (227)	90 Th Thorium 232.0381	91 Pa Protactinium 231.03688	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (288)	102 No Nobelium (259)	103 Lr Lawrencium (262)

'Picture' of an atom

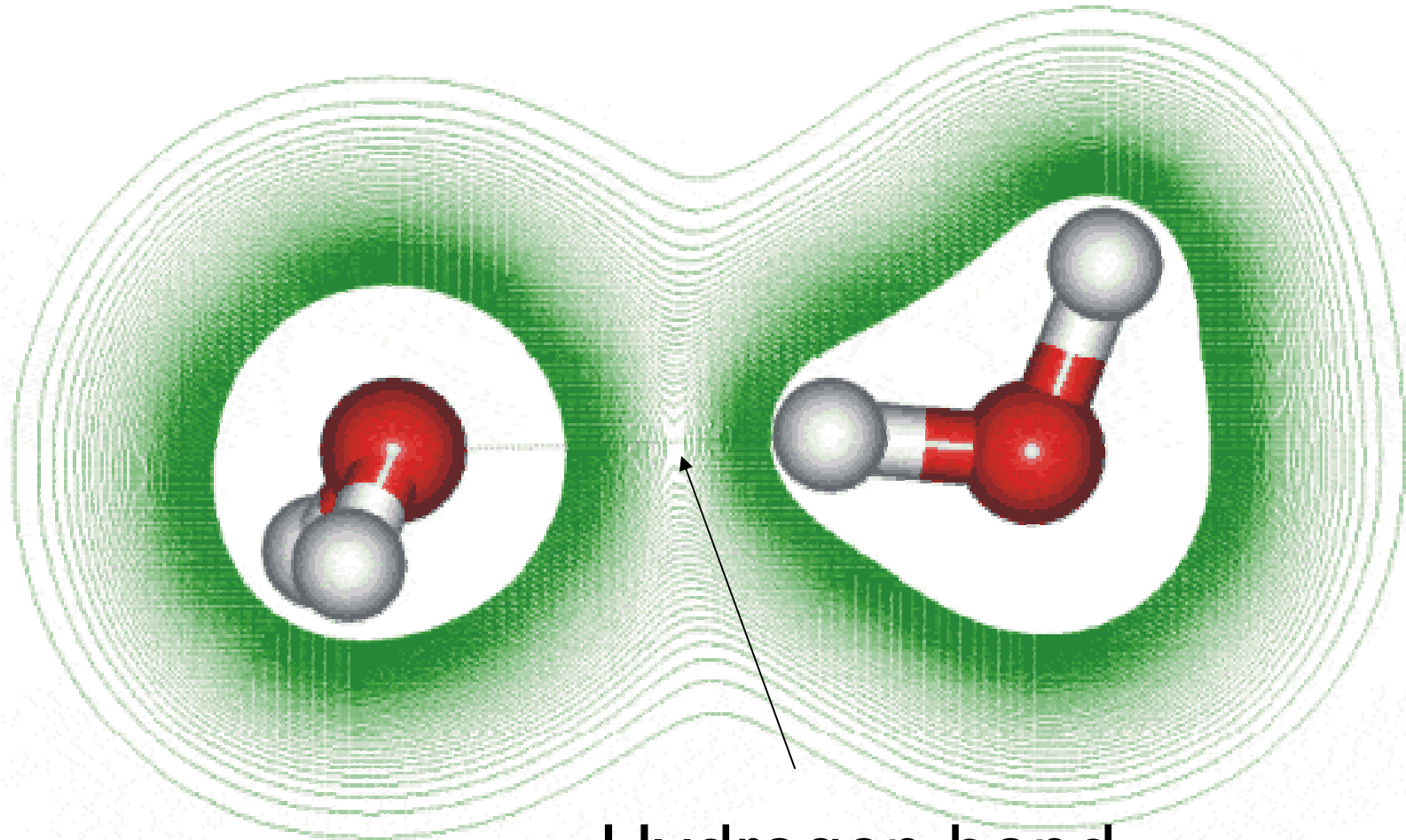


Molecules: Water



Electron density around the Oxygen atom
is 10x that around the Hydrogen atoms

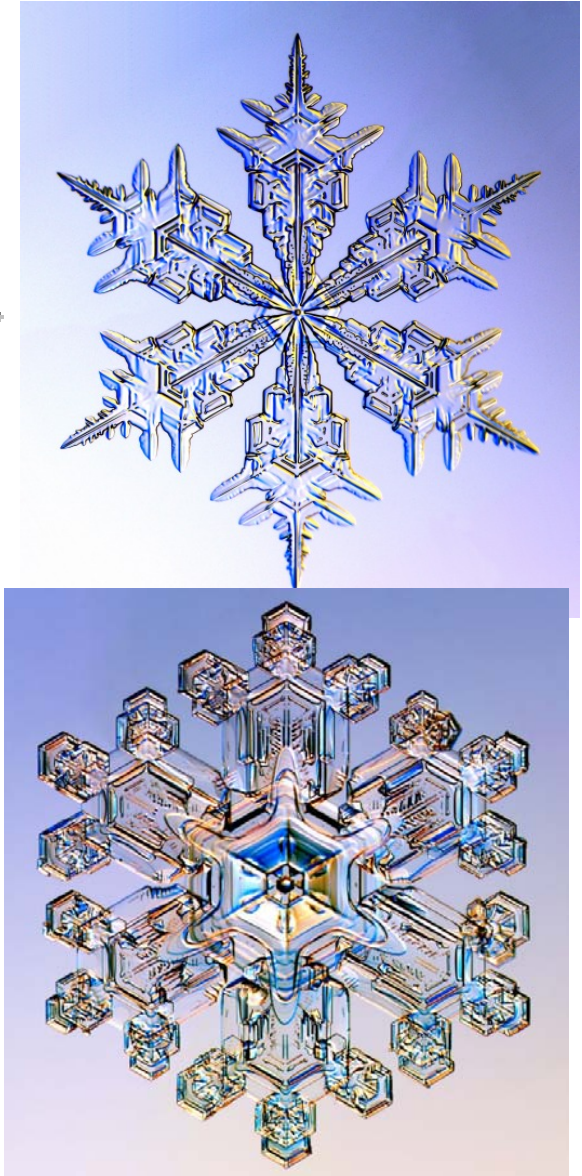
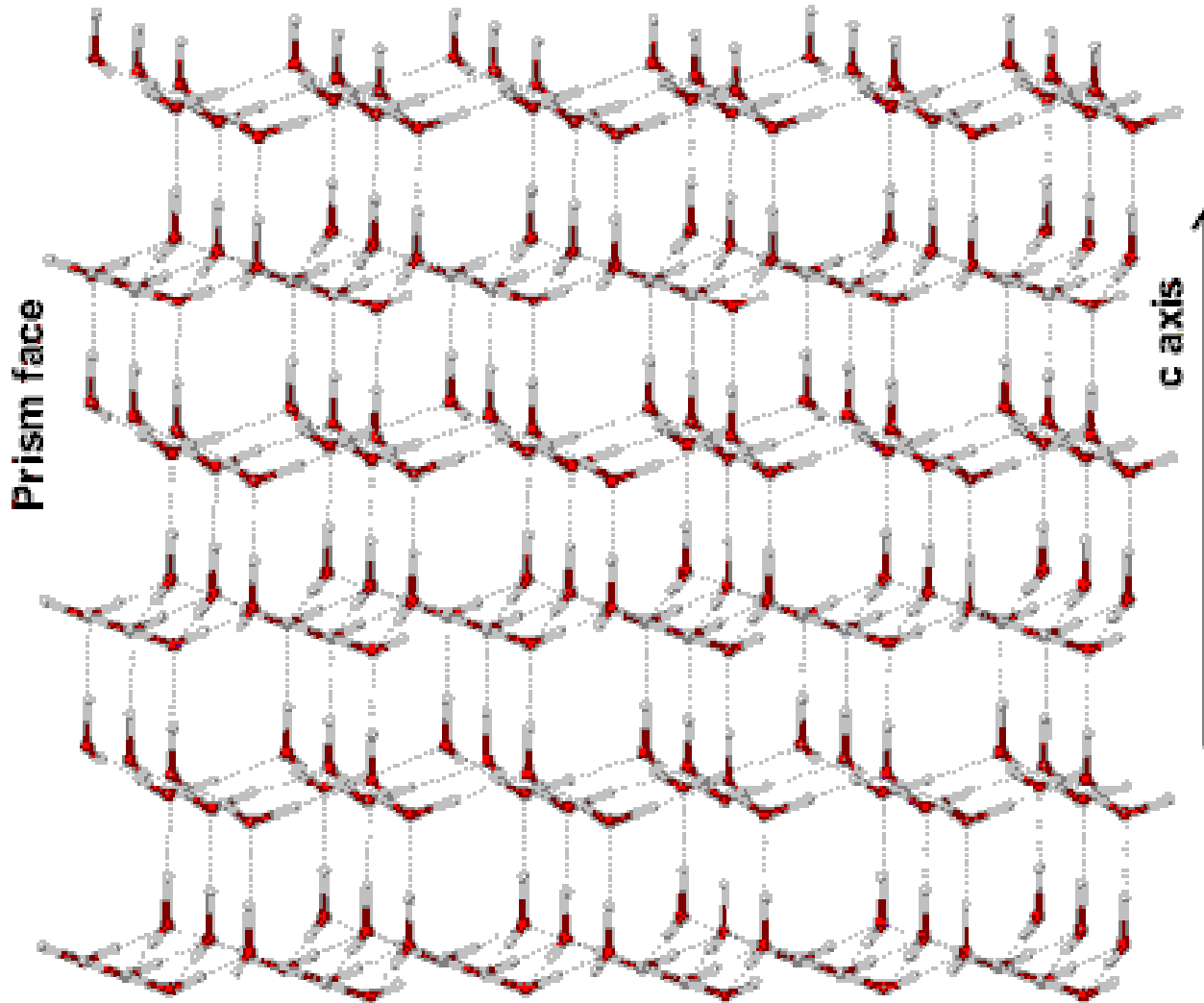
Dimer (2 water molecules)



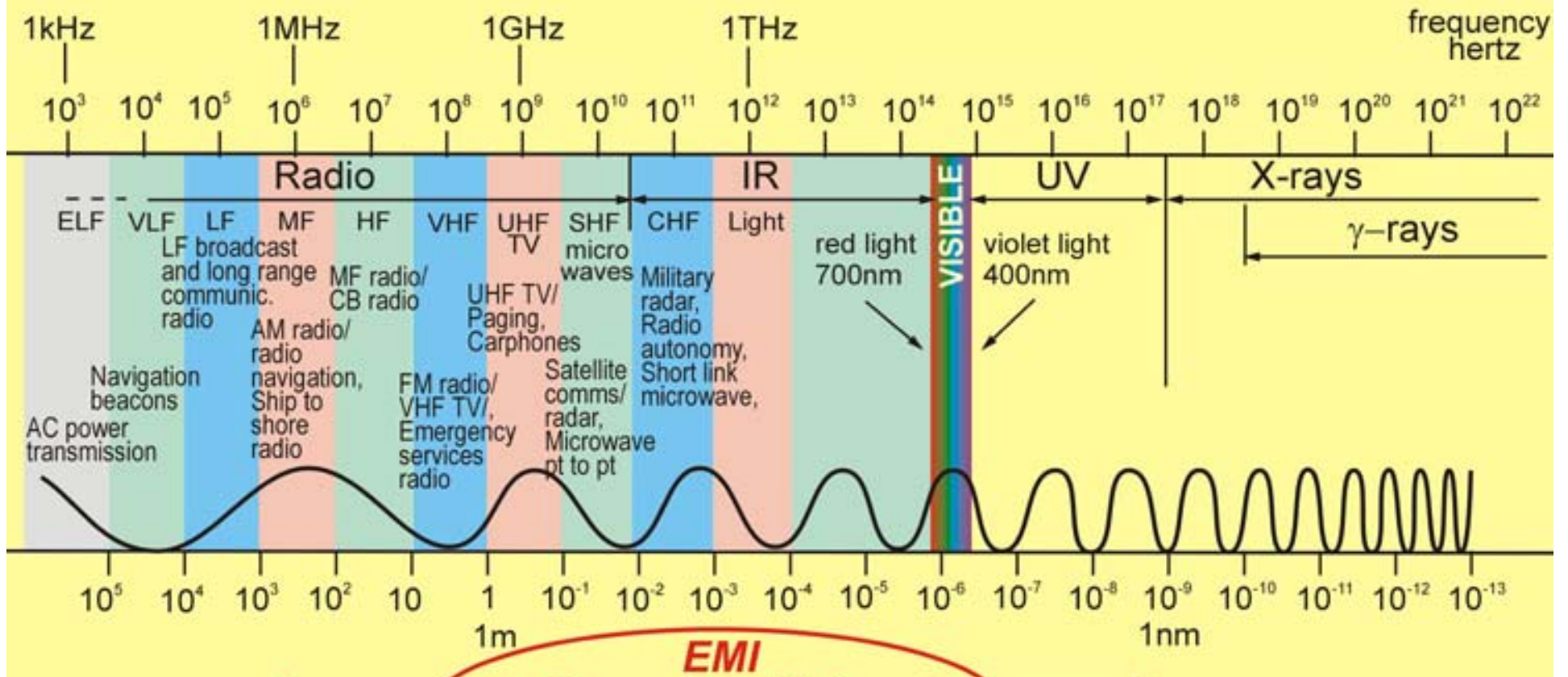
Hydrogen bond

Structure of Ice: Solid water (more is different!)

Basal plane



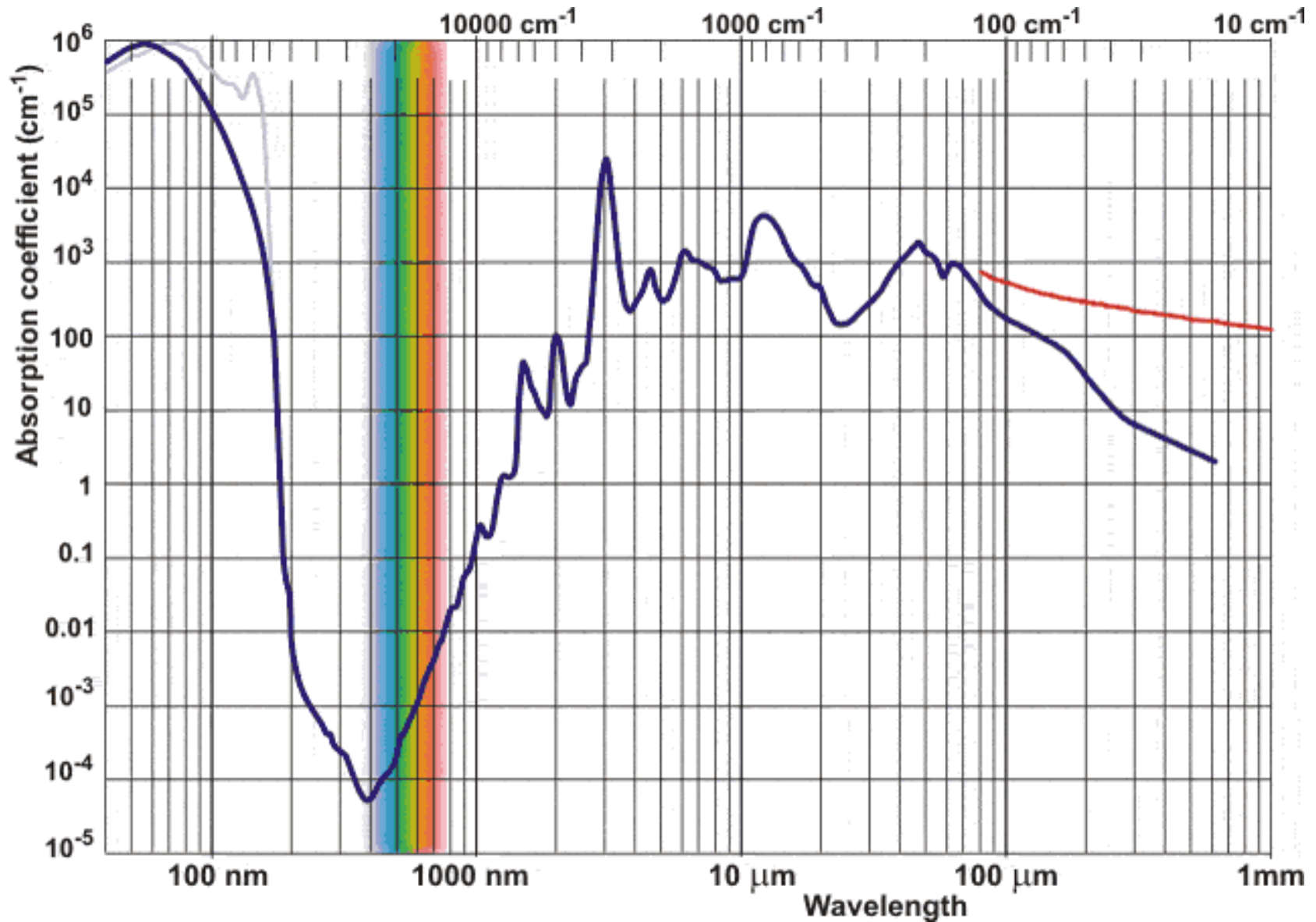
The Electromagnetic Spectrum



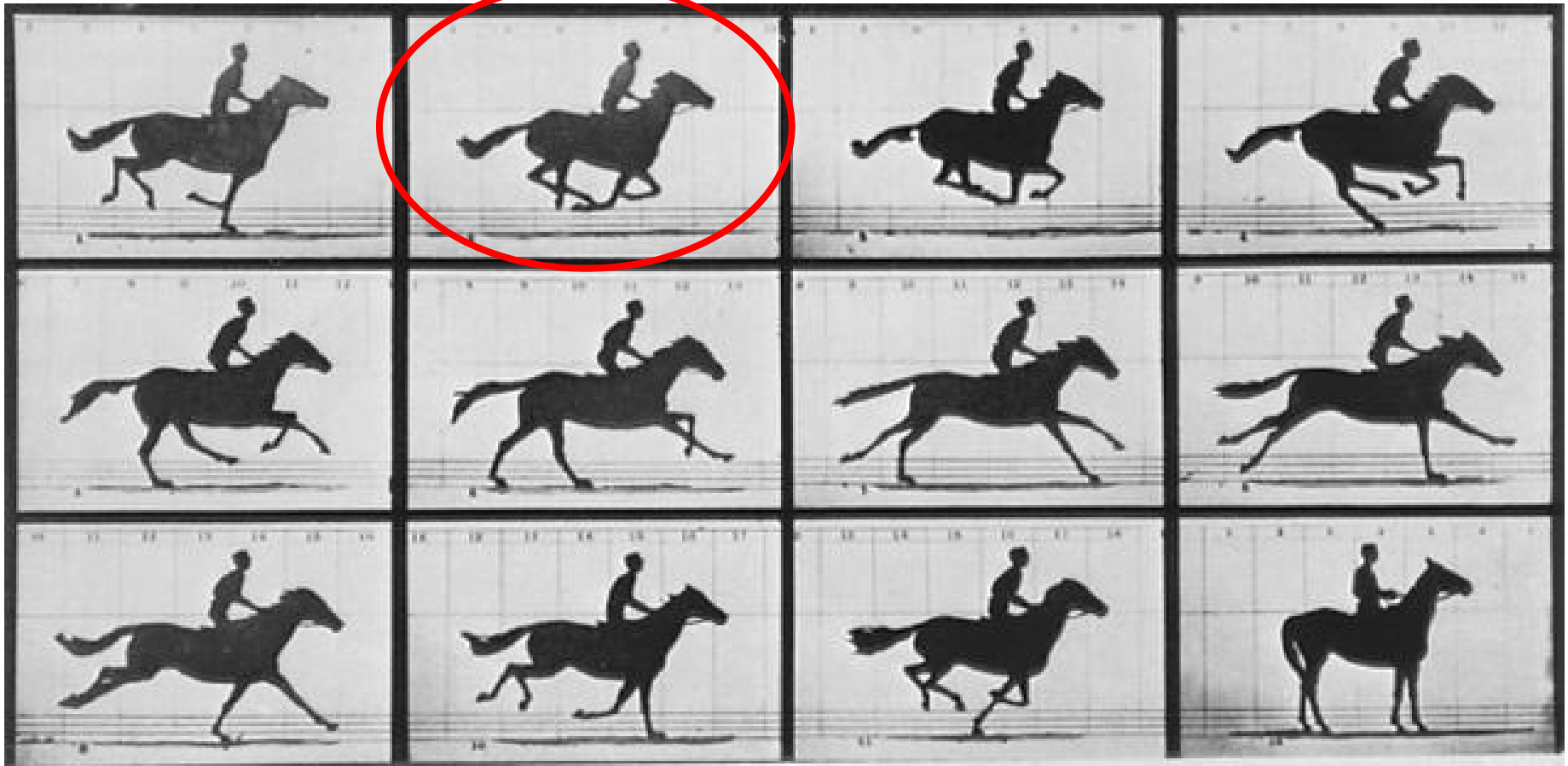
Laser lab in Amsterdam



Absorption Spectrum of Liquid Water



The Horse in Motion: Muybridge 1878



Copyright, 1878, by MUYBRIDGE.

MORSE'S Gallery, 427 Montgomery St., San Francisco.

THE HORSE IN MOTION.

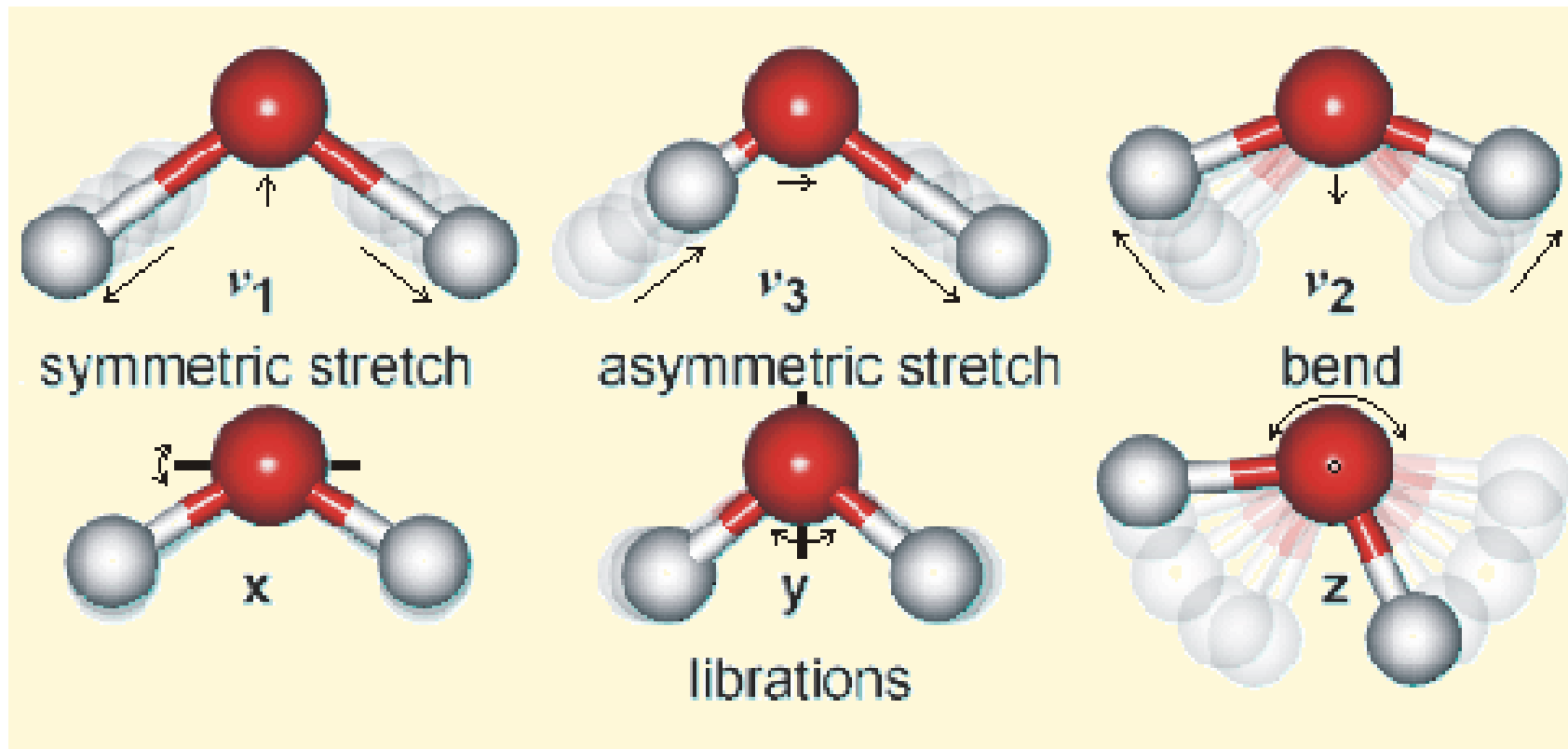
Illustrated by
MUYBRIDGE.

AUTOMATIC ELECTRO-PHYCOGRAPH

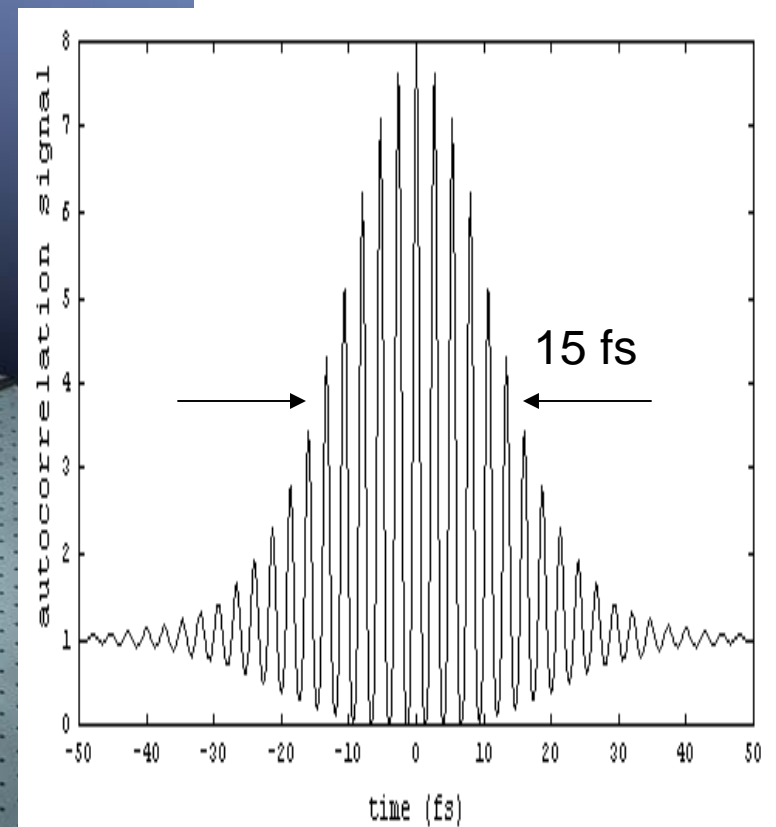
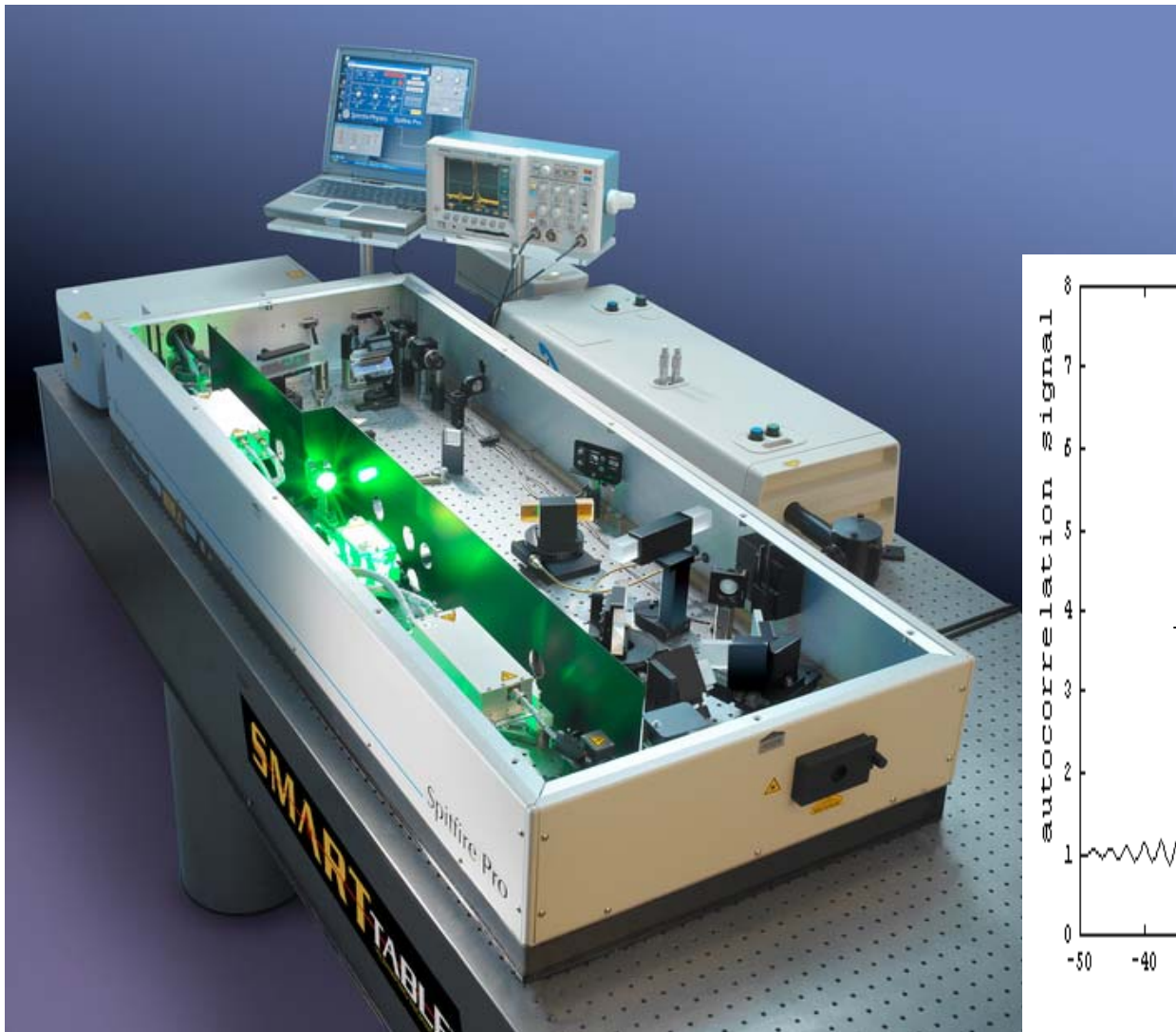
"SALLIE GARDNER," owned by LELAND STANFORD, running at a 1.40 gait over the Palo-Alto track, 19th June, 1878.

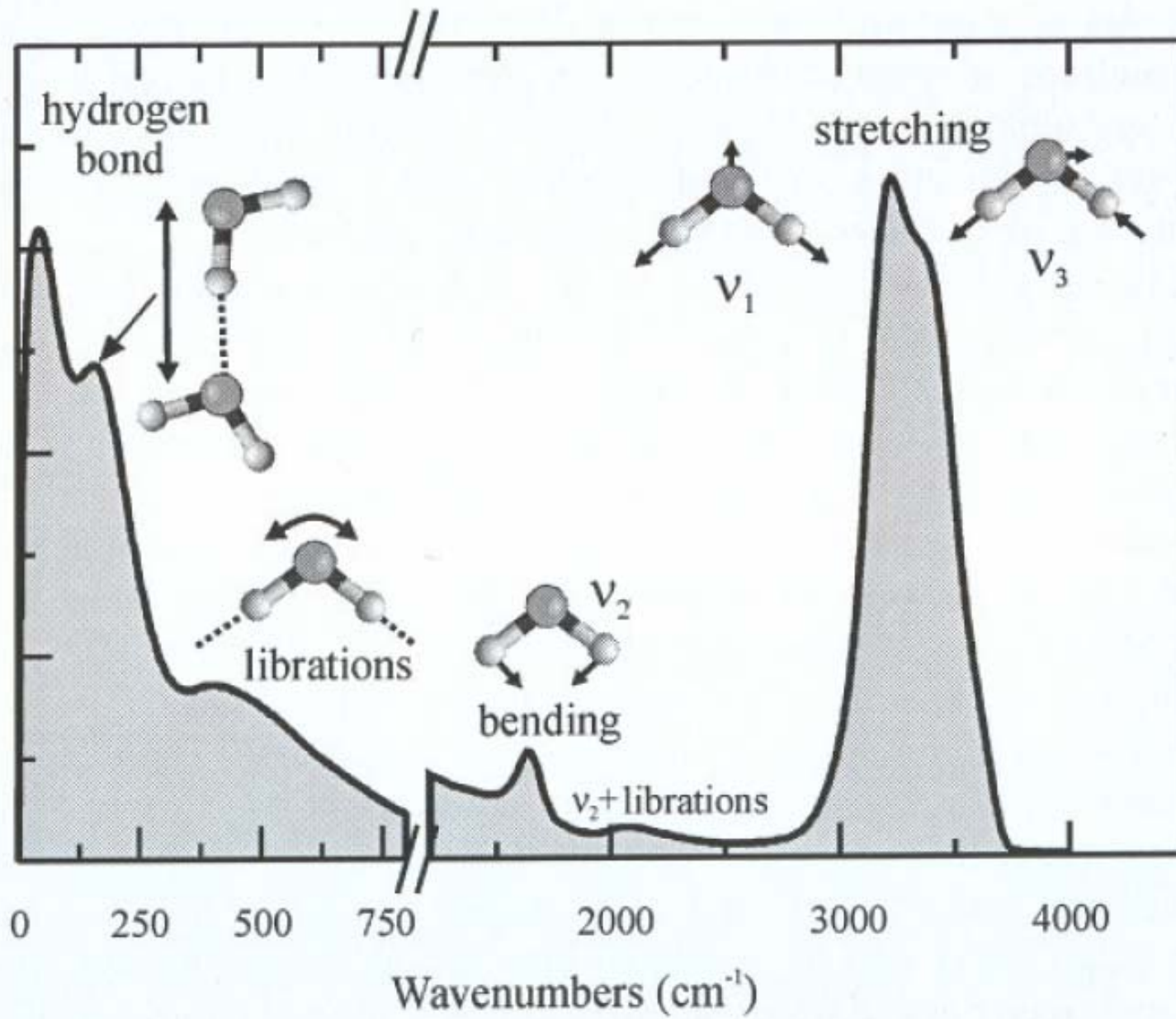
The negatives of these photographs were made at intervals of twenty-seven inches of distance, and about the twenty-fifth part of a second of time; they therefore represent positions assumed within twenty-seven inches of progress during a single stride of the horse. The vertical lines were twenty-seven inches apart, the horizontal lines represent elevations of four inches each. The exposure of each negative was less than the two-thousandth part of a second.

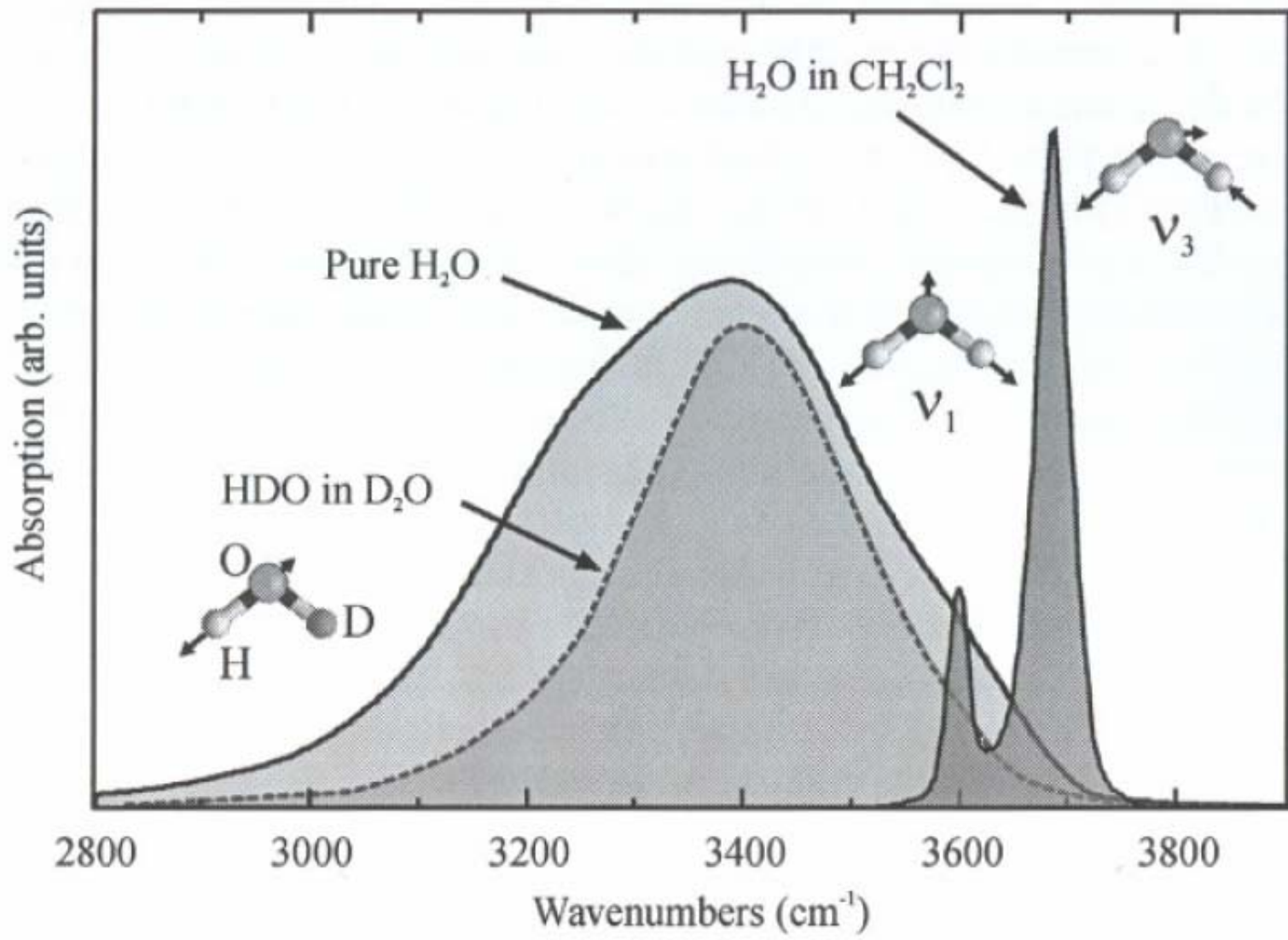
Water Molecule Vibrations

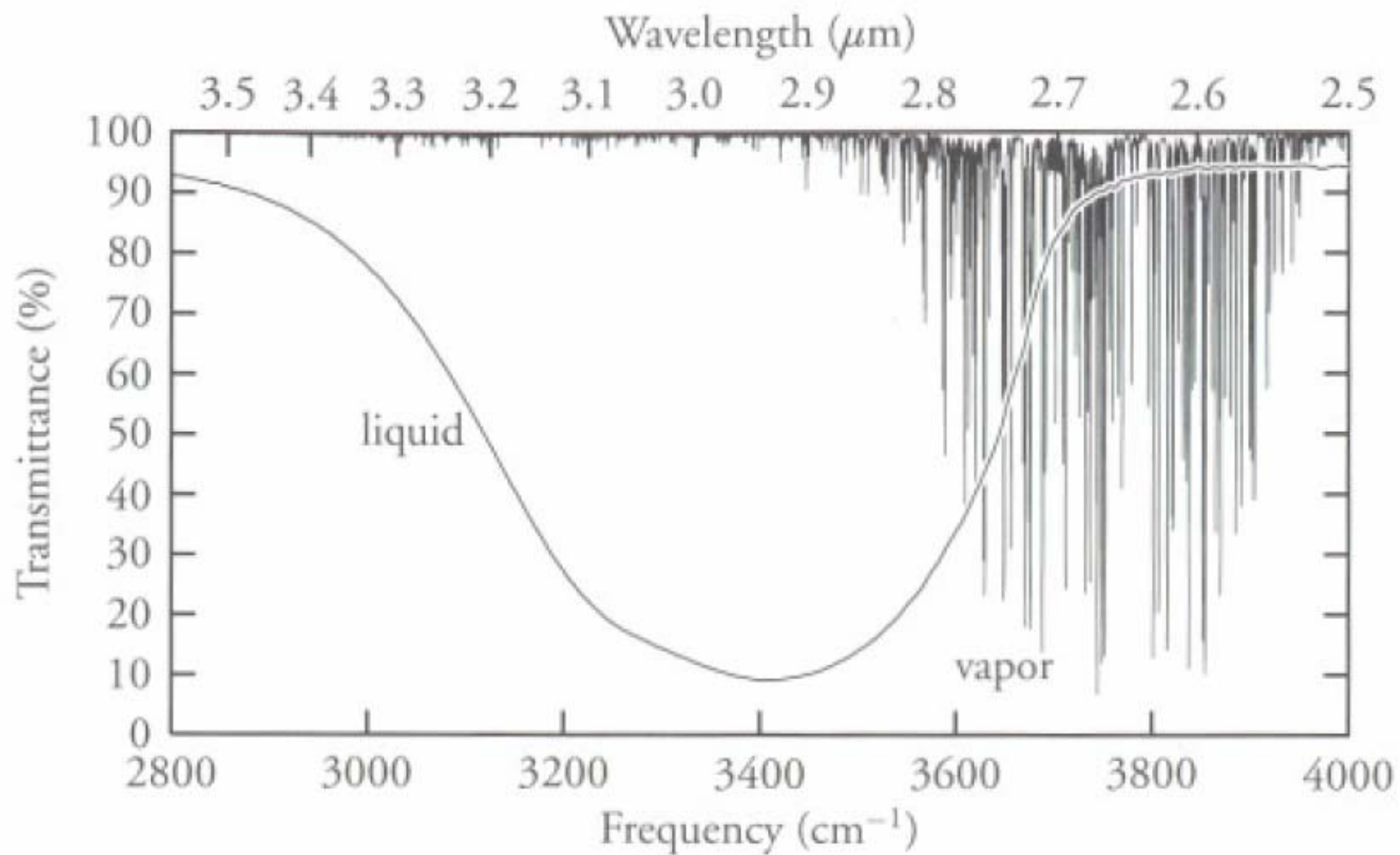


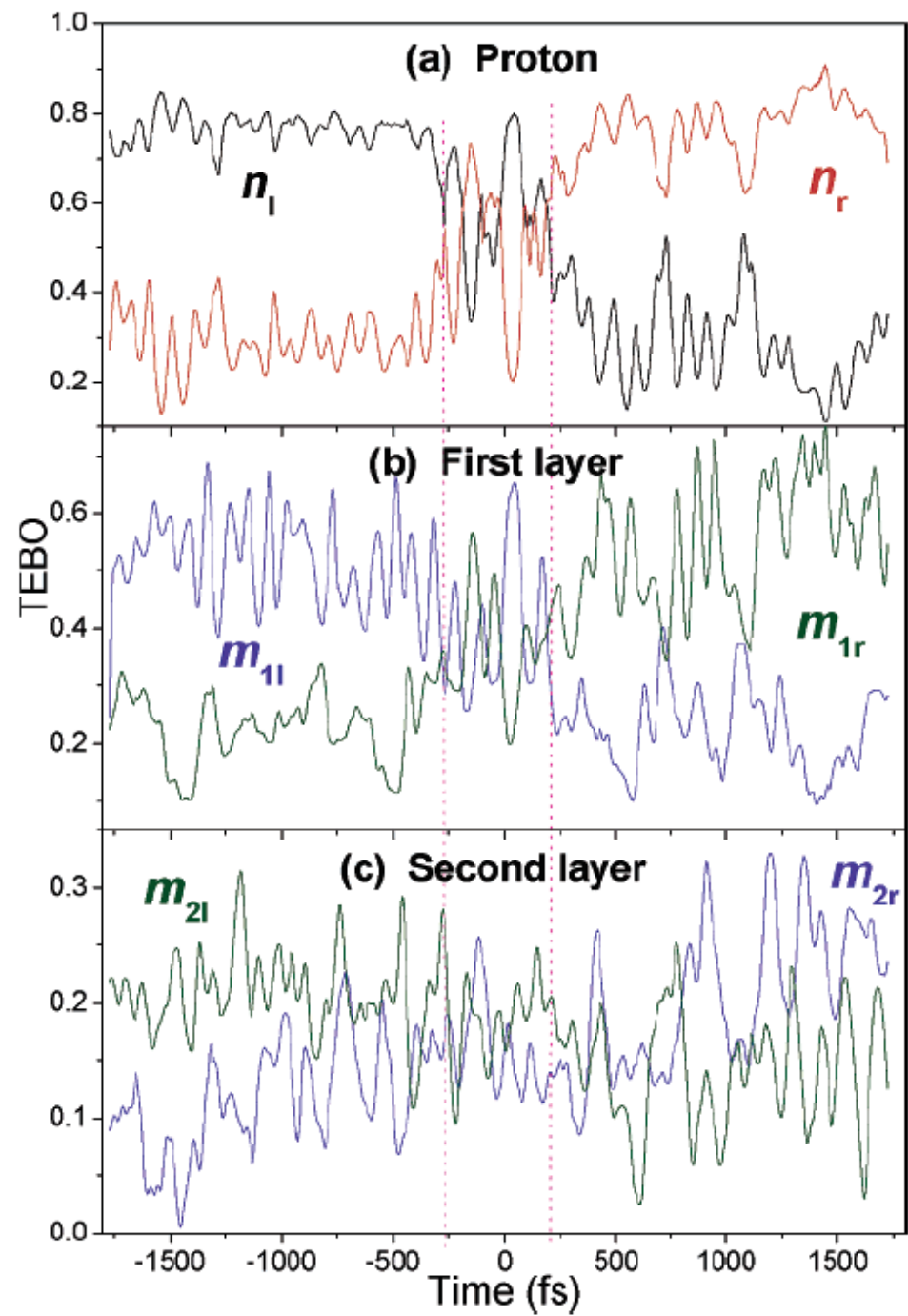
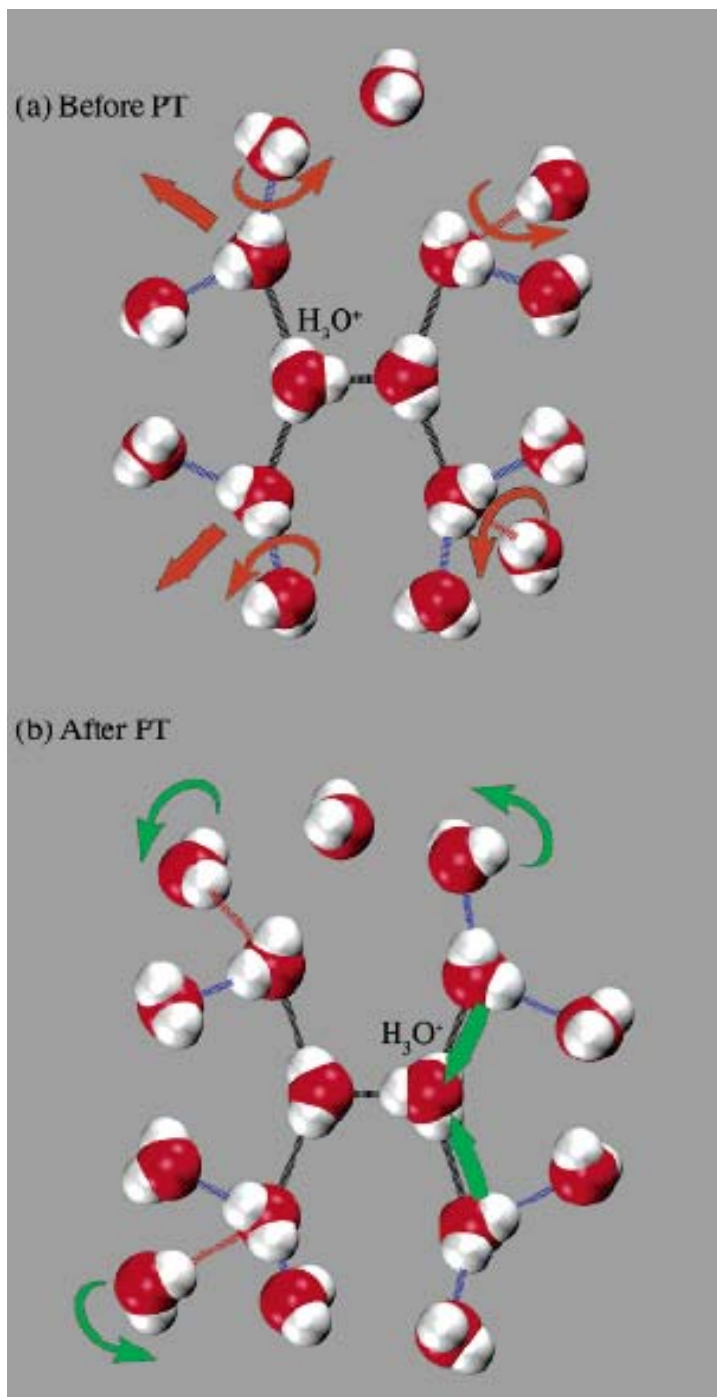
Femtosecond lasers



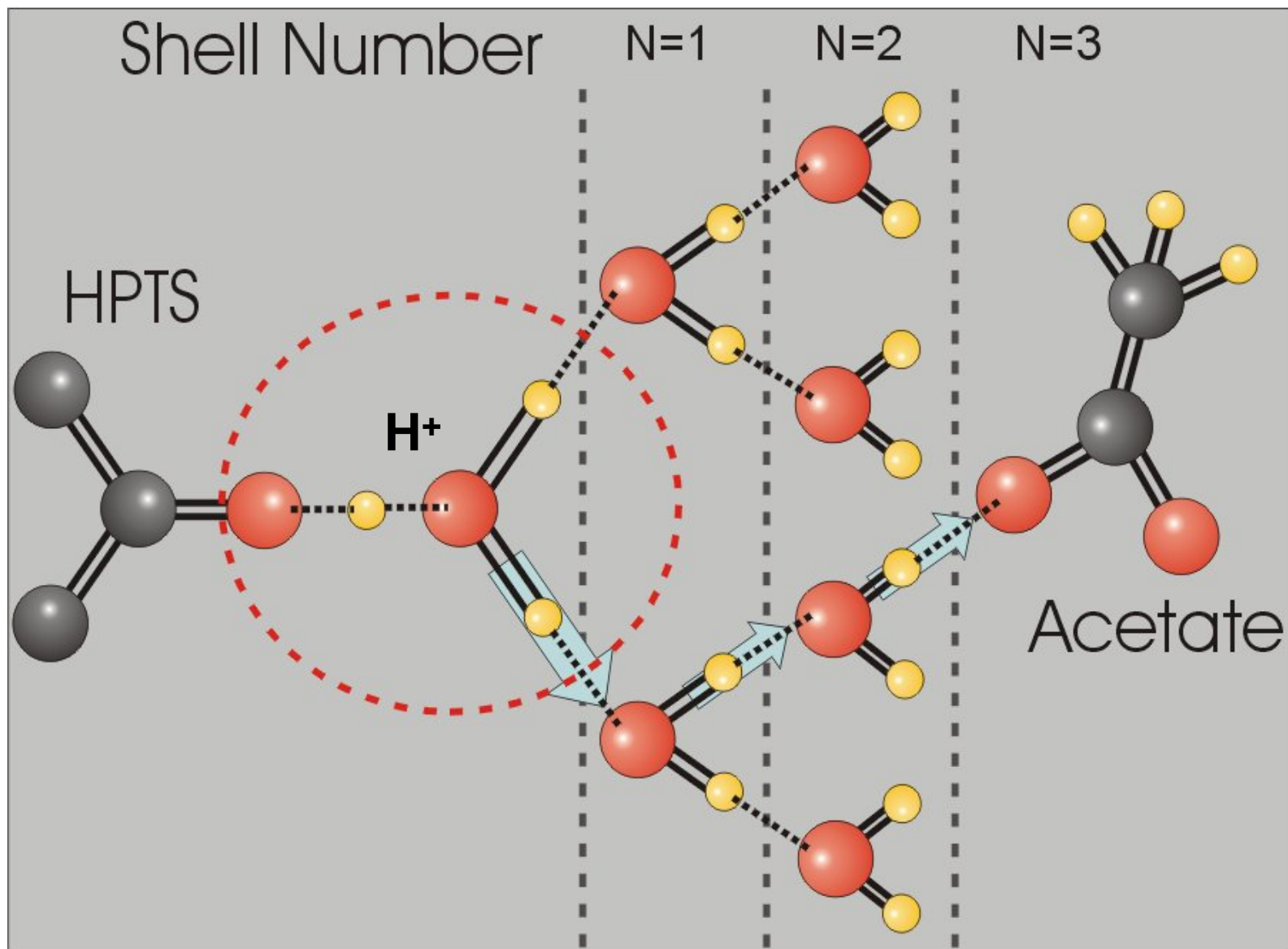




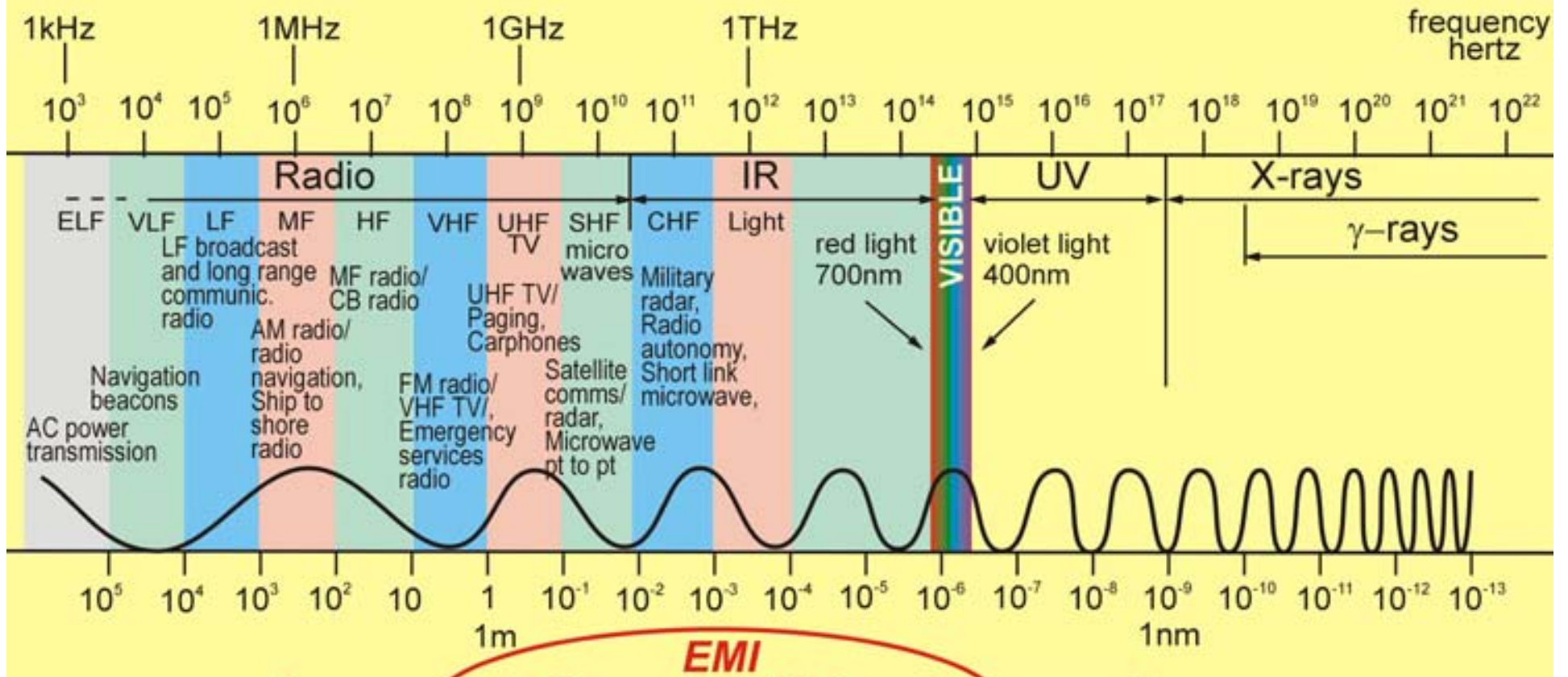




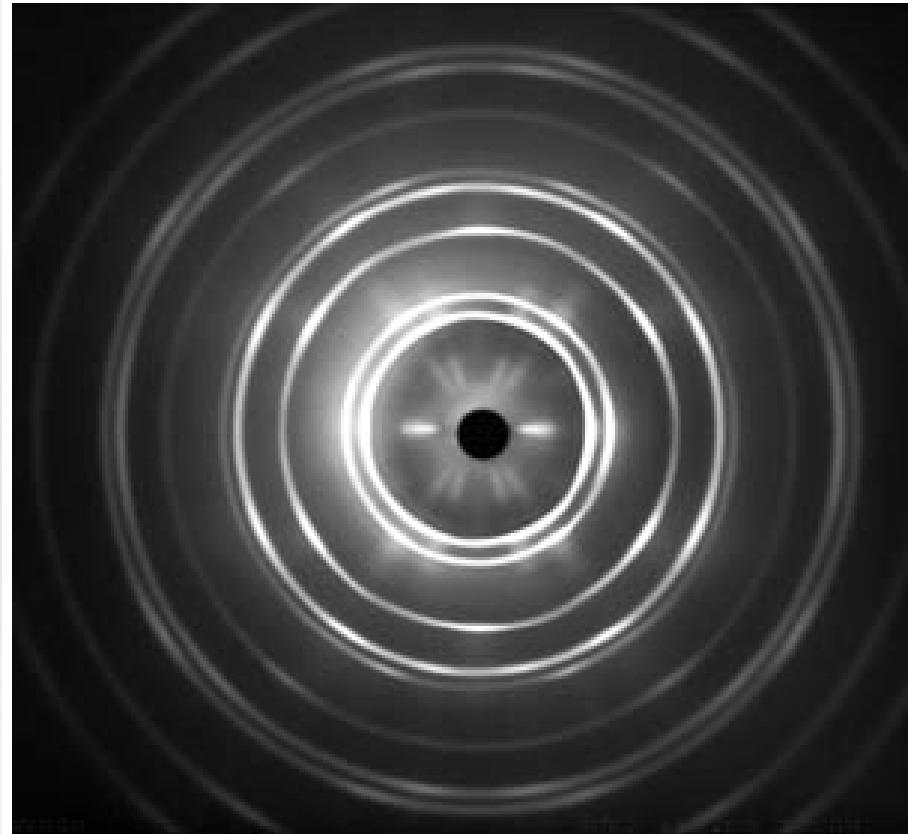
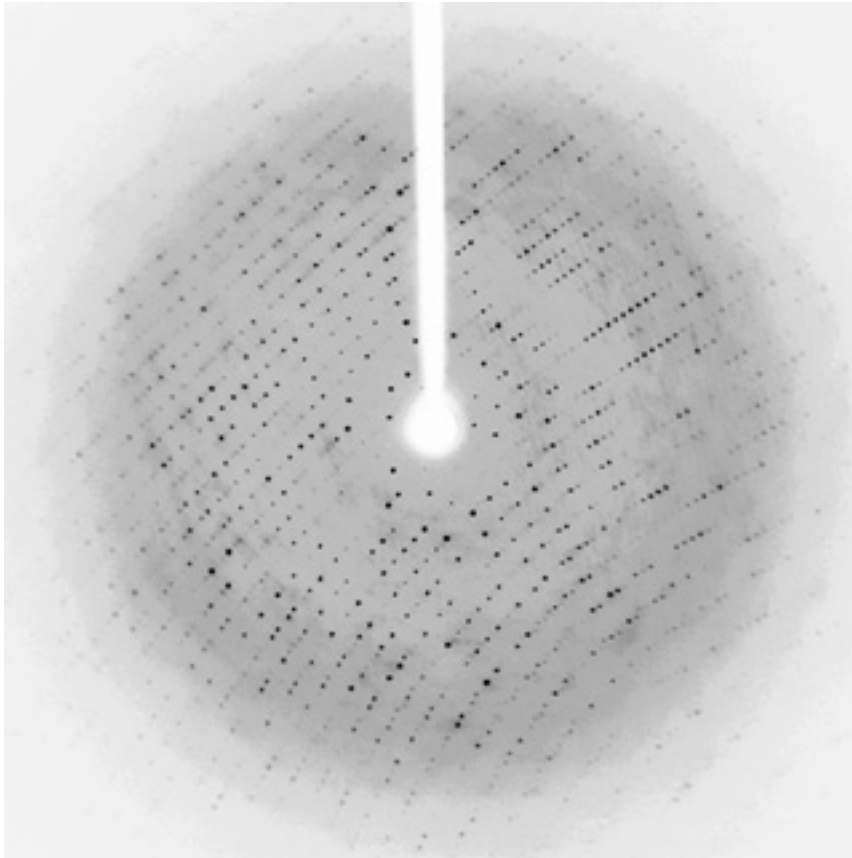
Intermolecular Proton Transfer



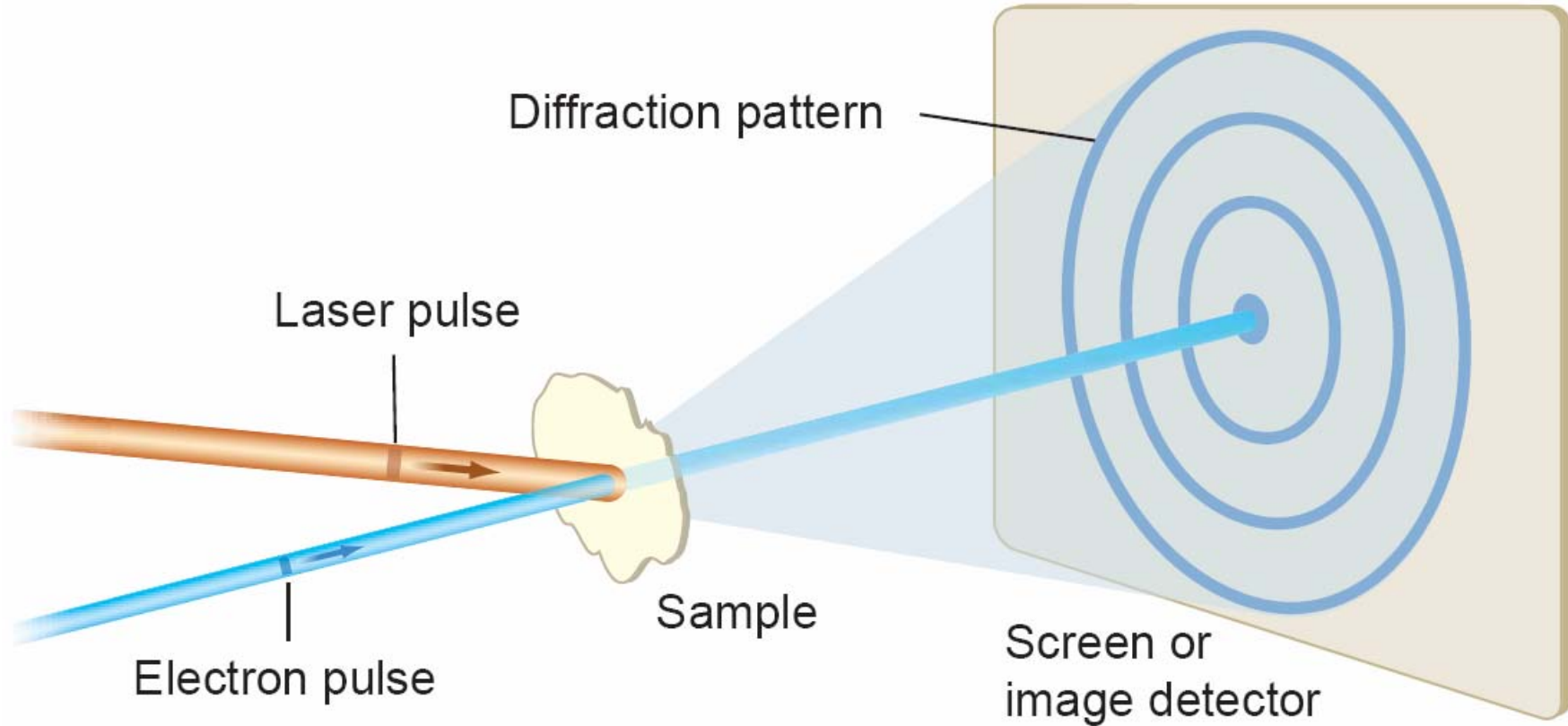
The Electromagnetic Spectrum



Diffraction Patterns: Learning about the arrangement of atoms

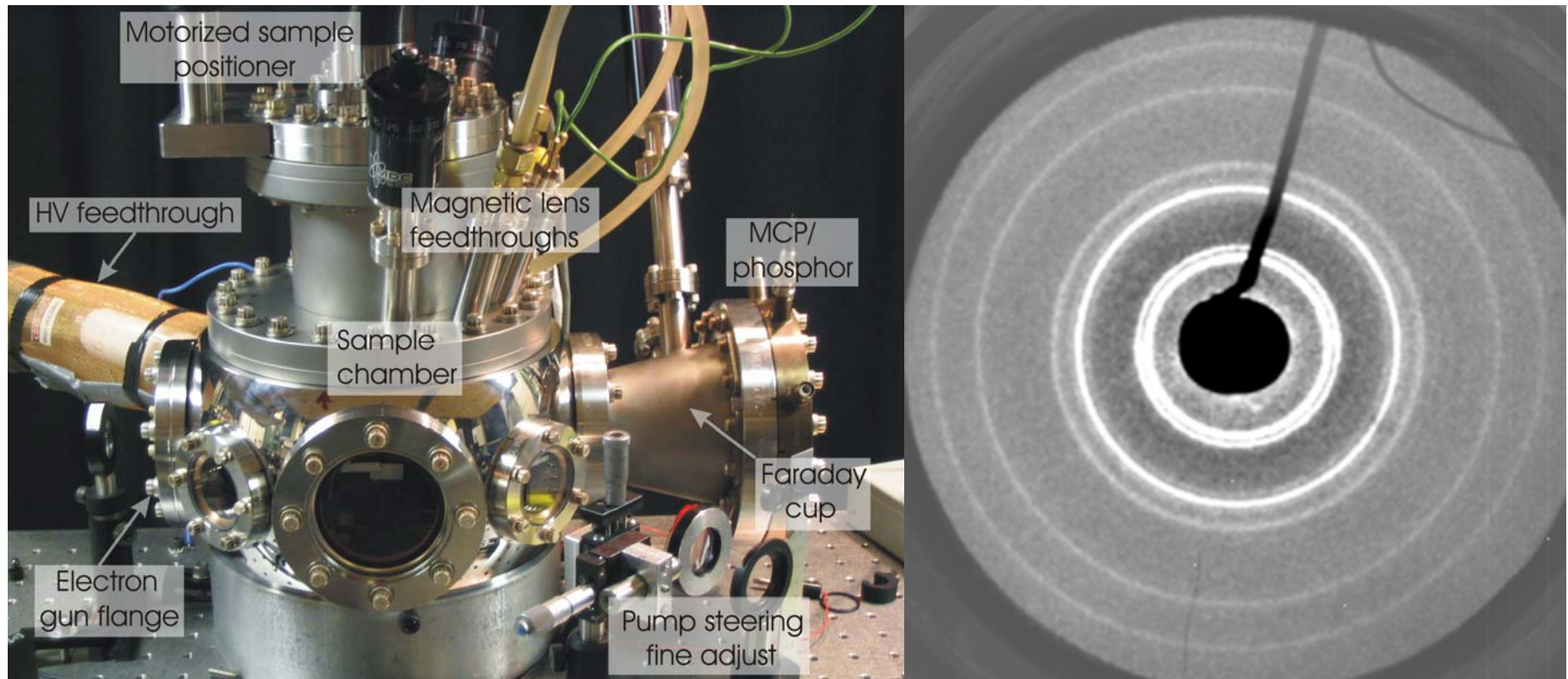


Making Movies of Molecules with Ultrafast Electron Diffraction

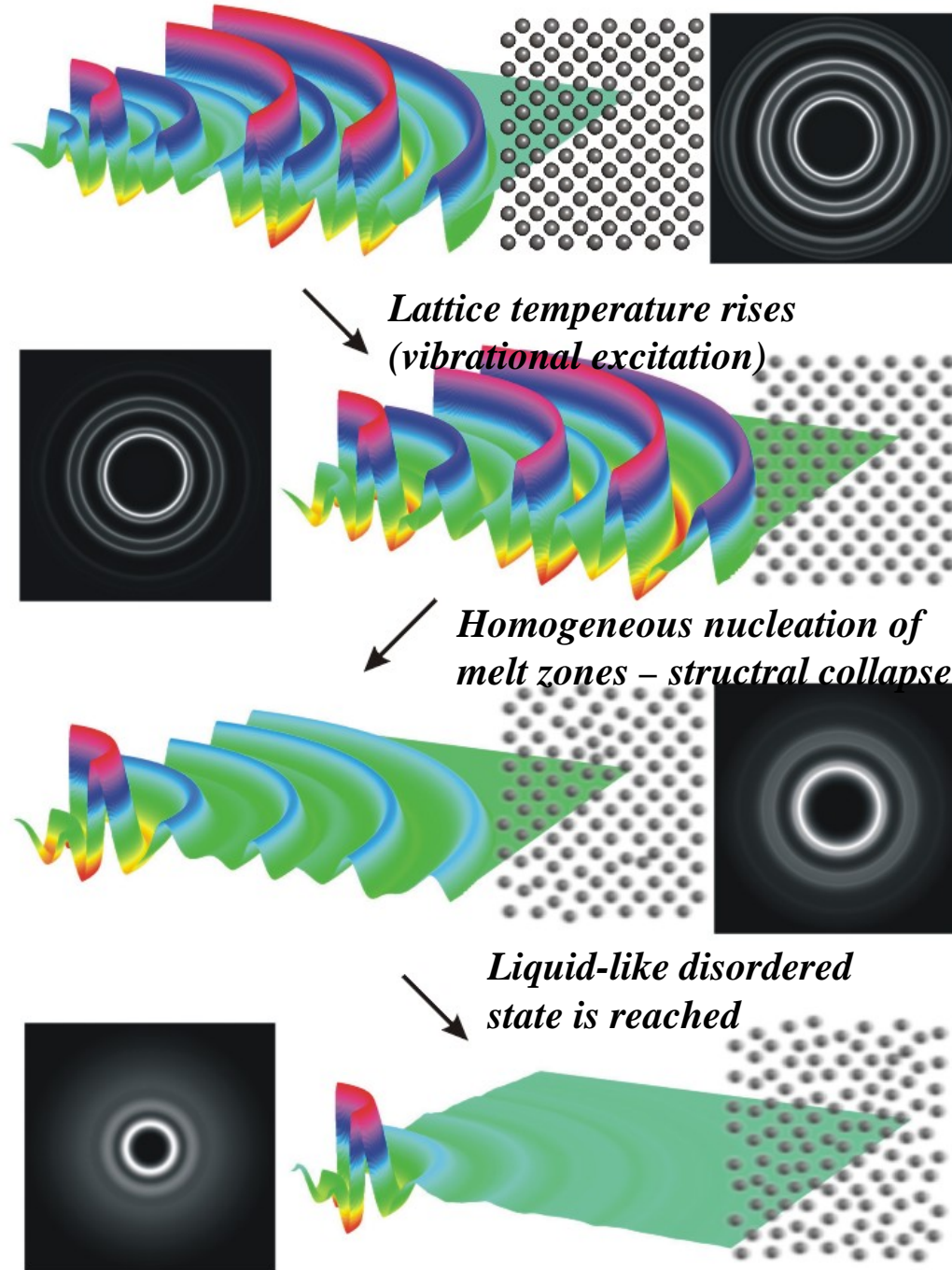


UED is a stroboscopic technique that can determine the 'instantaneous' atomic configuration of molecules and materials during photoinduced processes

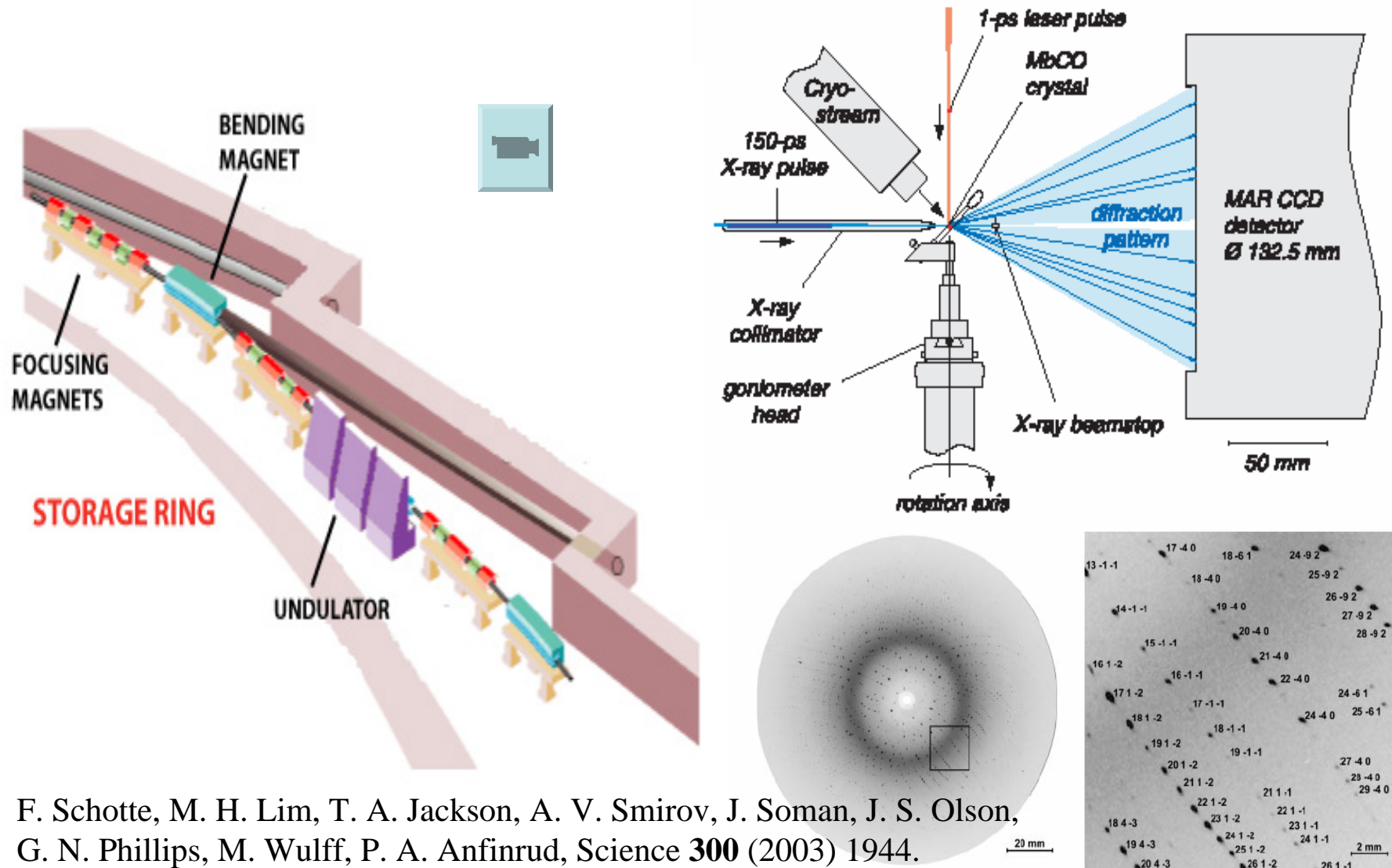
Ultrafast ($t < 10^{-10}$ s) diffractometer



An atomic level view of melting



Time-Resolved (150 ps) X-ray Crystallography at the ESRF



F. Schotte, M. H. Lim, T. A. Jackson, A. V. Smirov, J. Soman, J. S. Olson, G. N. Phillips, M. Wulff, P. A. Anfinrud, *Science* **300** (2003) 1944.

Watching a Protein as it Functions

F. Schotte, M. H. Lim, T. A. Jackson, A. V. Smirov, J. Soman, J. S. Olson, G. N. Phillips, M. Wulff, P. A. Anfinrud, *Science* **300** (2003) 1944.

