Copenhagen

QFM Plenary Lecture, November 1, 2011

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Readers: Mona Bagasao, Lee Irby, and Norm Smith

I. **Margarthe:** *But why?* (p.3)

II. **Heisenberg:** *…Everyone understands uncertainty. Or think he does…* (p.4)

III. **Margarthe:** *Father and son.* (p. 5)

IV. **Heisenberg:** *…Modern atomic physics began when Bohr realized that quantum theory applied to matter as well as to energy…* (p. 5)

A. Bohr model of atom

B. Complementarity (Wave/Particle Duality):

1. localized	2. bend around corner
3. bend around corner	4. collide with one thing at a time
5. faster means more energy	6. pass through two doors at once

V. **Bohr:** *This is physics.*
Margarthe: *This is also politics.* (p.18)

A. Science and politics: Global Warming.

B. Physics: Fission and Chain Reactions

C. Politics: Weapons of Mass Destruction, Nuclear Arms…

VI. **Heisenberg:** *You never had the slightest conception of what happens when bombs are dropped on cities.* (p. 43)

VII. **Heisenberg:** *… the choice is in our hands! In mine — in Oppenheimer's!* (p. 44)

VIII. **Margarthe:** *…and why didn't you?...Because you couldn't. You didn't understand the physics.* (p. 79)

IX. **Margarthe:** *… That's what it came down to in the end, all that shining springtime in the 1920s, that's what it produced—a more efficient machine for killing people.*
Bohr: *It breaks my heart every time I think of it.* (p.79)

Timeline

From Copenhagen, Text Timeline, PBS:
http://www.pbs.org/hollywoodpresents/copenhagen/timeline/timeline_text.html

			
1880's		-Bohr b. Oct 7, 1885 Copenhagen, Denmark	
1890's	-Electrons Discovered, Thomson, 1895		
1900's	-Quantum Theory: Energy in discrete packets (quanta), 1900 -Photoelectric effect: Electrons as particles (Einstein), 1905	-Heisenberg b. Dec 5, 1901 Wurzburg, Germany	
1910's	-Bohr Atom: Electrons in discrete orbits (quantization in atome), 1913 -General Relativity, Einstein, 1915	-Bohr, PhD, 1911 -Niels & Margarthe marry, 1912	-WWI begins, 1914 -Germany surrenders, 1918
1920's	-Matter as Waves: wavelength of particle, deBroglie, 1924 -Quantum Mechanics: matrix formulation of quantum mechanics, Heisenberg, Born 1925 -Schrodinger Wave Equation of Quantum Mechanics: formal solution for quantum mechanics, Schodinger, 1926 -Uncertainty Principle: can not know both position and momentum of a particle Heisenberg, 1927 -Copenhagen Interpretation: understanding quantum mechanics in terms of wave/particle duality and uncertainty, Bohr, 1928	-Bohr & Heisenberg meet, 1922 -Bohr Nobel Prize, 1922 -Heisenberg starts working in Copenhagen, 1924 -Bohr & Heisenberg present Complementarity, 1927	
1930's	-Neutron discovered, Chadwick, 1932 -Transmutation of Uranium: Uranium bombarded with neutrons (turns out to be fission, but unknown at this time), Fermi, 1934 -Nuclear Liquid Drop Model: explanation of nuclear properties, Bohr, 1937 -Fission, Meitner & Frisch, 1939	-Heisenberg Nobel Prize, 1933 -Bohr helps German Jews escape, 1939	-Hitler comes to power, 1933 -Eistein letter to Roosevelt warning about possible German bomb program, 1939 -WWII begins, 1939
1940's	-Critical mass calculation, Frisch & Peierls, 1940 -First nuclear reactor, Fermi, 1942 -Trinity Test: First atomic bomb, July 16, 1945	-Copenhagen meeting, 1941 -Bohr escapes Denmark, 1943 -Bohr works on Manhatten Project, 1944 -Heisenberg held at Farm Hall, Englan, May-Oct, 1945	-Pearl Harbor, 1941 -Manhattan Project begins, 1942 -Germany surrenders, May 8, 1945 -Hiroshima: atomic bomb dropped, August 6, 1945 -Nagasaki: atomic bomb dropped, August 9, 1945 -Japan surrenders, Aug 10, 1945