Captured Kindle Notes on Dave, February 2021.

QUANTUM: Einstein, Bohr, and the Great Debate about the Nature of Reality, Kumar, Manjit, 2009 ~ 400 pages. CHAPTERS:

Cosmo Meeting Chapter 1: The Reluctant Revolutionary, 2. The Patient Slave, 3. The Golden DANE, 4. The quantum atom, 5. When Einstein Met Bohr, 6. The Prince of Duality (p143), 7. SPIN doctors, ('Boy Physics' Part II, 156).
8. The quantum magician (p 177) ,
Meeting Two: 9. A late Erotic outburst p 201, 10. Uncertainty in Copenhagen p 225 , 11. Solvay 5 **1927**. Chapter 12. Einstein Forgets Relativity 281. 13. Quantum Reality p 301 , Part 4, Does God Play Dice. Chapter 14, 'For whom Bell's theorem Tolls, p 331. . 15. The Quantum Demon. 351.

> **Reality and the SOUL of Physics.** Kindle location 194/9629
> Emit/absorb quanta end points versus a photon or electron in the middle !?
> {-- "**without being anywhere in the middle" ??}**

'No more profound intellectual debate has ever been conducted', claimed the scientist and novelist C.P. Snow. 'It is a pity that the debate, because of its nature, can't be common currency.' Kum**ar, Manjit. Quantum** . Icon Books Ltd. Kindle Edition.

"Yet for most of the twentieth century, physicists accepted that quantum mechanics denied the existence of a reality beyond what was measured in their experiments. It was a state of affairs that led the American Nobel Prize-winning physicist Murray Gell-Mann to describe quantum mechanics as 'that mysterious, confusing discipline **which none of us really understands** but which we know how to use'.

QUANTUM optics text by Fox: on photoelectric effect p 3. Major effects "…can in fact be understood by treating **only the atoms as quantized objects and** the light as a classical electromagnetic wave." called **SEMI-CLASSICAL**
{very few physicists really know detailed history of physics}.

P11 If a hot body at 500 degrees loses 1000 units of energy to a colder body at 250 degrees, then its entropy has decreased by **–1000/500 = –2.** The colder body at 250 degrees has gained 1000 units of energy, +1000/250, and its entropy has increased by 4. The overall entropy of the system, the hot and cold bodies combined, has increased by 2 units of energy per degree. All real, actual processes are irreversible because they result in an increase in entropy. Kumar, Manjit. Quantum (p. 11). Icon Books Ltd. Kindle Edition. L430.

19 Rubens explained that his latest measurements left no room for doubt: Wien's law failed at long wavelengths and high temperatures. Those measurements, Planck learnt, revealed that at such wavelengths the intensity of blackbody radiation was proportional to the temperature.

30 First, Wien's Law was OK at short wavelengths. Second, it failed in the infrared where Rubens and Kurlbaum had found that intensity was proportional to the temperature $\propto$ T. Third, Wien's displacement law was correct. "Planck had to find a way to assemble these three pieces of the blackbody jigsaw together to build the formula.

He never explicitly quantised individual oscillators, as he should have done, but only groups of them.

33 Einstein's revolutionary 'point of view' was that light, indeed all electromagnetic radiation, was not wavelike at all but chopped up into little bits, light-quanta. For the next twenty years, virtually no one but he believed in his quantum of light {the photon}.

49 BlackBody Electromagnetic radiation… like the particles of a gas, Einstein knew that he had smuggled his light-quanta in through the back door, by analogy. To convince others of the 'heuristic' value of his new 'point of view' concerning the nature of light, he used it to explain a little-understood phenomenon. The German physicist Heinrich Hertz first observed the photoelectric effect in 1887

51 At best some thought that light, and therefore all electromagnetic radiation, did not consist of quanta, but only behaved as such when exchanging energy with matter. (a wise semiclassical belief)

53 If light was really made of {Newton's} particles, where was the evidence of collisions occurring when two beams of light crossed each other? There was none, argued **Huygens**. Sound waves do not collide; ergo light must also be wavelike. {photons do not interact with photons--??!! … Dirac:, a photon interferes only with itself, not other photons – not quite true).

57 **In 1819** the Danish physicist Hans Christian **Oersted** discovered that an electric current flowing through a wire deflected a compass needle. A year later the Frenchman François Arago found that a wire carrying an electric current acted as a magnet and could attract iron filings. Soon his compatriot André Marie **Ampère** demonstrated that two parallel wires were attracted towards one another if each had a current flowing through it in the same direction.

Michael **Faraday** decided to see if he could generate electricity using magnetism. He pushed a bar magnet in and out of a helix coil of wire …

63 Presentations: It was the first prediction of what would later be called wave-particle duality – that light was both a particle and a wave. Planck, who was chairing, was the first to speak after Einstein sat down. He thanked him for the lecture and then told everyone he disagreed.

86 1910: Yet the fact that radiothorium, radioactinium, ionium, and uranium-X were all chemically identical to thorium was strong evidence in favour of Soddy's **isotopes**.

101 About Bohr: Clues: electrons don't step on each other because they have quantized orbits. **John Nocholson** suggested L = n$\hbar$. Then There was obviously a link between an atom and its spectral lines, but at the beginning of February 1913 Bohr had no inkling what it could be. **Hans Hansen** suggested that he take a look at Johann Balmer's formula for the spectral lines of hydrogen. (ie.,biggest clues came from others)

108 Moseley predicted the existence of missing elements with atomic numbers 42, 43, **72** and 75 {Mo, Tc, Hf, Re} on the basis that each element produced a characteristic set of X-ray spectral lines and those adjacent to each other in the periodic table had very similar ones. All four were later discovered, but by then Moseley was dead… When the First World War began he enlisted

109 A more significant turning point in its acceptance {Bohr Atom} came in April 1914, when the young German physicists James Franck and Gustav Hertz bombarded mercury atoms with electrons and found that the electrons lost 4.9 eV of energy during these collisions.

111 It was at the beginning of 1915 that he changed his mind as new experiments revealed that the red, blue and violet Balmer lines were **all** doublets. Using his atomic model, Bohr could not explain this 'fine structure', {Sommerfeld explained this with new elliptical orbits. Then he added a magnetic quantum number for the tilt of orbits to help explain the Zeeman and Stark effects}. So now there was a "Bohr-Sommerfeld Atom."

117 By the time he returned from the first Solvay conference in November 1911 on 'The Theory of Radiation and the Quanta', **Einstein** had decided that **enough was enough and pushed the lunacy of the quantum to one side.** Over the next four years, as Bohr and his atom took centre stage, Einstein effectively abandoned the quantum to concentrate on extending his theory of relativity to encompass gravity.

124 …spectra, but Einstein now revealed a third effect: '**stimulated emission'.** It occurs when a light-quantum strikes an electron in an atom that is already in an excited state. Instead of absorbing the incoming light-quantum, the electron is 'stimulated', nudged, to leap to a lower energy, emitting a light-quantum.. Einstein also discovered that light-quanta had momentum, (3. LASER principle, 1. Absorption, 2. Spontaneous emission – random probabilistic **like a "half-life"** – A_{21} these three can give Planck BB, he used BB as an input). He knew that causality was at risk – an **APPLE hovering** above the ground and suddenly on earth. – still struggling with the idea in 1924. $dn_2/n_2 = -A_{21}dt$,

133 BOHR made a prediction. The unknown element with atomic number **72 {Hafnium,** Hf—the ancient name for Copenhagen – it would become the "crowning glory" of Bohr's later Shell model} would be chemically similar to zirconium, atomic number 40, and titanium, atomic number 22, the two elements in the same column of the periodic table. It would not, Bohr said, belong to the 'rare earth' group of elements that were on either side of it in the table, as predicted by others. (periodic column)

139 Compton found that the wavelengths of the scattered X-rays were always slightly longer than those of the 'primary' or incident X-rays. According to the wave theory they should have been exactly the same. He understood that the difference in wavelength (and therefore frequency) meant the **secondary X-rays** were not the same as the ones that had been fired at the target.

Aside GOOGLE: a Plasma physics journal 2018: …high-intensity laser-matter interactions and astrophysical environments such as neutron star magnetospheres. When the energy of the photon becomes comparable to that of the electron, it is necessary to use quantum electrodynamics (QED) to describe the dynamics accurately. However, computing the appropriate scattering matrix element from strong-field QED is not generally possible due to **multiparticle** effects and the complex structure of the electromagnetic fields. Therefore, these interactions are treated **semiclassically**, coupling probabilistic emission events to classical electrodynamics using rates calculated in the locally constant field approximation. Here, we provide comprehensive benchmarking of this approach against the exact QED calculation for nonlinear Compton scattering of electrons in an intense laser pulse. We find **agreement at the percentage level** between the photon spectra, as well as between the models' predictions of absorption from the background field,

And also https://core.ac.uk/download/pdf/291545572.pdf Raman, 1928

140 The 'Compton effect', the increase in wavelength of X-rays when they are scattered by electrons, was irrefutable evidence for the existence of light-quanta, which until then many had dismissed at best as science fiction.
[NOT TRUE!] Books present physics history without detailed corrections that might get in the way of a good story.

Aside: "The Compton effect, perhaps the phenomenon most frequently cited as evidence of the quantum nature of radiation, is thus given a classical explanation which yields the Klein-Nishina cross section and demonstrates the classical origin of photon-like behavior of the incident and scattered radiation. Further confirmation of the classical nature of the electromagnetic field at the quantum mechanical level is presented in a new derivation of the Lamb shift, another famous phenomenon whose only acceptable explanation has been quantum electrodynamical. A more complete discussion of the $c_1(t)$ and $c_2(t)$ transition coefficients is also carried out, leading finally to new semiclassical treatments of spontaneous emission and the blackbody spectrum. Classical theory of radiative transitions, Barwick, J.T.F. II. 1979

142 1924 Einstein a full explanation of Compton's experiment and the photoelectric effect could not be provided without recourse to the **quantum theory of light.** Light had a dual, wave-particle character, which physicists just had to accept.

146 … during the year 1923, that the discovery made by Einstein in 1905 should be generalized by extending it to all material particles and notably to electrons. **deBroglie** had dared to ask the simple question: if light waves can behave like particles, can particles such as electrons behave like waves?
147 Broglie's idea of treating electrons as standing waves was a radical departure from thinking about electrons as particles orbiting an atomic nucleus. Standing waves Kumar, Manjit. Quantum Icon Books Ltd. Kindle Edition. A standing wave has no acceleration **so no EM decay.**
151… the British Association for the Advancement of Science conference. It was there that Davisson was astonished to learn that some physicists believed that the data from his experiment supported the idea of a French prince. He had not heard of de Broglie or his suggestion that wave-particle duality be extended to encompass all matter. Davisson was not alone. Few people had read …

Pauli's Exclusion Principle was posed in 1924. (no two electrons could take on the same 4 quantum numbers, n, k, m, s .).
167 … all the possible values that the quantum numbers k and m could take, and was equal to $2n^2$. Stoner's rule yielded the correct series of numbers 2, 8, 18, 32 … for the elements in the rows of the periodic table. But why was the number of electrons in a closed shell twice the value of N or n^2? Pauli came up with the answer – **a fourth quantum number had to be assigned to electrons in atoms.**
disagreement with classical relativity physics meant an end to the **old** quantum theory.

186 The Bohr-Sommerfeld quantum atom could account for the frequency of hydrogen's spectral lines, but not how bright or dim they were. Heisenberg's idea was to **separate what was observable and what was not.** The orbit of an electron around the nucleus of a hydrogen atom was not observable. So Heisenberg decided to abandon the idea of electrons orbiting the nucleus {I think that is probably wise now—no overt particles there—**the "wave" is more than a wave}.**

Aside: Wheeler: GREAT SMOKEY DRAGON with origin at tail and detection at head and a wide whatever inbetween. NO ORBITS. {**But**, on 2D surfaces there **are** Landau orbits like Bohrs for quantum Hall effect).
{ELECTRON SPIN with L as J = L + S together. L determines B-field enabling S spin to be up or down. – but QED doesn't give electron spin all by itself}.

Physics had to **break free** (Pauli, Bohr, Heisenberg) – no classical prejudices – go observables first—positivist first – new types of causes second.

190 Energy=Frequency Array in a matrix-- levels. If an electron quantum jumps from the energy level E2 to the lower energy level E1, a spectral line is emitted with a frequency designated by ν_{21} in the array. The spectral line of frequency ν_{12} would only be found in the absorption spectrum, and a Transition probability matrix A_{mn} for Intensities -- Similar to energy momentum matrices.}

{I SUSPECT ERROR here: electron at great distance orbit falls to small orbit and emits radiation at frequency of rotation (at great distance). $\Delta E = 1/\infty + E_n$. NO!
But Charge on a rotating string, f of rotation does = f of A {vector potential} wave. The book is ignoring the nucleus's electric potential}
I get $f = v/2\pi r$, $E_n = \hbar f_n \pi n = \mathbf{(hf_n) n/2}$, like a halfway n value.
Frequency of rotation is not the frequency of quantum jump emission. !
190 "physics, the orbital frequency of an electron in such an exaggerated orbit, the number of complete orbits it makes per second, is equal to the frequency of the radiation it **emits**." {Classical without quantum emission} IF IT EMITTED CLASSICAL A FIELD WHILE ROTATING.

197 Even more remarkably, Born soon discovered that Dirac had sent his paper to the Proceedings of the Royal Society containing the nuts and bolts of quantum mechanics a **whole nine days before the 'three-man paper' was finished.** Who was Dirac and how had he done it, wondered Born?
199 'What I wanted was statements which could be expressed in terms of equations,' he said later, 'and Bohr's work very seldom provided such statements.'

208 …40pages/year, but. In **1926 he published 256 pages** in which he demonstrated how **wave mechanics** could successfully solve a range of problems in atomic physics. He also came up with a time-dependent version of his wave equation that could tackle 'systems' that changed with time. Among them were processes involving the absorption and emission of radiation…

212 Two months earlier, Heisenberg had appeared more conciliatory when he described wave mechanics as 'incredibly **interesting'**. But those who knew Bohr recognized that Heisenberg was employing exactly the sort of language favoured by the Dane, who always called an idea or an argument 'interesting' when in fact he disagreed with it. 214… there was a question that Schrödinger was finding difficult to answer: **what was doing the waving?** (Still a big question, clock vibration of the particle).
{most fundamental basis is that all rest masses have a fundamental frequency $f = mc^2/h$ –- $E=hf$, and $p = h/\lambda$ is just the Lorentz transformation of this with respect to some speed difference between object and observer. Schrodinger equation is merely a statement of conservation of energy: KE + PE = total E expressed via wave phases.

Energy IS the density of waves in time and momentum IS the density of waves in space}.

Comments: Schrodinger liked the charge density dq\dvolume = eψ*ψ -- but thought of it in a traveling wave-particle which doesn't work because it disperses and becomes TOO spread out —- **but how about standing waves – they don't disperse!!** I think dq =eψ*ψ applies to continually reinforced waves.

{And then, there is the **CONFIGURATION** space problem, how can you wave in 6 or higher dimensional space. {could **that be entanglement?.** !!! ??? Multi-particle entanglement. ?? Helium electrons **are** entangled}.

Aside Comments from other sources: GOOGLE comments: Rodney Brooks says NO, two γ's or e's have to be created together for entanglement to occur (no, not true).

LOW-TEMPERATURE PHYSICS RESEARCH UPDATE, Entangled electron pairs can be created using heat with split Cooper pairs,19 Jan 2021)

Aside: Journal But at a **quantum critical point**, things are so collective that we have this chance to see the effects of entanglement even in a metallic film that contains billions of billions of quantum mechanical objects." ""Electrons are in a strange state in superconducting materials," "Our goal is to use these superconductors to generate entangled, spatially separated electron pairs that behave as a single quantum object." … **any measurement of the spin of one of them is correlated with the spin measured on the other – no matter how far apart they are!** The 'non-locality' (e.g., Cooper Pairs).

"2015 — Physicists have developed a new technique that can successfully entangle 3000 atoms using only a single photon.

Helium: Because of the presence of the electron-electron interaction term $1/r_{12}$ in H, this equation is not separable, so that an eigenfunction ψ(r1,r2) cannot be written in the form of a single product of one-electron wave functions. The wave **functions are said to be entangled. !!**

Page 216 … uranium had to be accommodated in a space with 276 dimensions. The waves that occupied these abstract multi-dimensional spaces could not be the real, physical waves . {does the word entanglement apply to uranium electrons?}

219 Claim: "The wave function itself has no physical reality; it exists in the mysterious, ghost-like realm of the possible. It deals with abstract possibilities, like all the angles by which an electron could be scattered following a collision with an atom.
Born argued that the square of the wave function, a real rather than a complex number, inhabits the world of the probable. (an guess that worked well – we enter a new world of "probability amplitude" – **for all practical purposes FAPP.**

For Meeting Two in March 2021: p 226 Chapter 9 Uncertainty:

'it is quite wrong to try founding a theory on observable magnitudes alone'. 'In reality the very opposite happens. It is the theory which decides what we can observe.' What did Einstein mean? .

228 Heisenberg said later-- Nothing caused them more pain than **wave-particle duality.** As Einstein told Ehrenfest: 'On the one hand waves, on the other quanta! Is an electron now a particle or a wave. Heisenberg was a particle guy.

230 in September 1926 {Dirac in Copenhagen} for a six-month stay, showed that matrix and wave mechanics were just special cases of an even more abstract formulation of quantum mechanics called transformation theory.
233 … UNCERTAINTY PRINCIPLE March 1927 $\Delta p \Delta q \geq \hbar$ and $\Delta E \Delta t \geq \hbar$. Arthur Compton, in 1923, had investigated X-rays striking electrons and found conclusive evidence for the existence of Einstein's light-quanta {**No**, not quite true}. Heisenberg imagined that, like two billiard balls colliding, when a gamma ray photon hits the electron, it is scattered into the microscope as the electron recoils.

Heisenberg was motivated by cloud chamber tracks, but what is the relevance here. His math was Matrix mechanics (but Fourier transforms for waves). He used $[p,q] = -i\hbar$ measuring p first or q first gives different answers.

236 The very idea of an electron with a definite 'position' or 'momentum' is meaningless prior to an experiment that measures it {but deBroglie/Bohm interpretation is a counter-example – the impossible done}. Heisenberg had adopted an approach to defining concepts through their measurement that harked back to Ernst Mach and what philosophers called operationalism. But it was more than just a redefinition of old concepts. … The only thing that is known for certain, says Heisenberg, is one point along the path, and 'therefore here the word "path" has no definable meaning'. It is measurement that defines what is being measured. … There is no way of knowing, argued Heisenberg, what happens between two consecutive measurements:
{another motivation was Pauli October 1926 seeing with a p-eye vs a q-eye}
{But Heisenberg had forgotten about "resolving power" and needed waves to do it right as Bohr now insisted!}
{Then Bohr came up with **Complementarity**}

244 In other words, it was no longer possible to make the separation that existed in classical physics between the observer and the observed, between the equipment used to make a measurement and what was being measured. Bohr was adamant that it was the specific experiment being performed that revealed either the particle or wave aspects of an electron or a beam of light, of matter or radiation. Since particle and wave were complementary but mutually exclusive facets of one underlying phenomenon,

250 Heisenberg boldly asserted in the last paragraph of his uncertainty paper, 'it follows that **quantum mechanics establishes the final failure of causality.**' Any hope of restoring it was as 'fruitless and senseless' as any lingering belief in a 'real' world hidden behind what Heisenberg called 'the perceived statistical world'. It was a view shared by Bohr, Pauli and Born.

Part III p 252 Titans Clash Chapter 11, Solvay 1927
258 Presentation: mechanics. In conclusion, they made the provocative statement that 'we consider quantum mechanics to be a **closed theory**, whose fundamental physical and mathematical assumptions are no longer susceptible of any modification'. {Einstein and Schrodinger disagreed}.

262 observation. According to the Copenhagen interpretation, a microphysical object has no intrinsic properties. An electron simply does not exist at any place until an observation or measurement

An unobserved electron does not exist. 'It is wrong to think that the task of physics is to find out how nature is', Bohr would argue later. 'Physics concerns what we can say about nature.' Nothing more.

EINSTEIN THOUGHT EXPERIMENTS Key Arguments.

1. SINGLE SLIT, CYLINDRICAL SCREEN FIG 14 THEN FIG 15
   {Why can't the apparatus be heavy?} Einstein claimed "Ensemble" probability – Copenhagen says for each event.

265 "Sure, the wave function collapses instantaneously, they thought, but it was an abstract wave of probability, not a real wave travelling in ordinary three-dimensional space." {In opposition to the Copenhagen interpretation, Bohr never accepted the idea of the collapse of the wavefunction! – not Bohr's Copenhagen, just Heisenberg's}.
Bohr changed the experiment to one of trying to know both Δp and Δq. So Einstein addressed the movable screen problem – a deflection of argument.
Screen S1 supported by springs Fig 15→ 16. Δp_y goes with Δy which destroys the interference pattern. {Argument p 270 is hard}. GoTo Fig 17 open/close slits A or B
P 273 Bohr playing with the "Schnitt" or Heisenberg Cut, choosing to be classical or quantum. The early debate was more uncertainty principle rather than interpretation.

277 Dirac …Professor of Mathematics at Cambridge University in September 1932, a chair once occupied by Isaac Newton, **Dirac was never interested** in the question of **interpretation**. It seemed to him to be a pointless preoccupation that led …

280… (Einstein after being deathly ill for a year) … continuing to challenge what was becoming the quantum orthodoxy, the Copenhagen interpretation. When they met again in Brussels at the sixth Solvay conference in **1930**, Einstein presented Bohr with an imaginary box of light. Brussels 6th Solvay Conference. P 284 Figure 18
286 … box affected the time-keeping of the clock inside. The position of the light box in the earth's gravitational field is altered by the act of measuring the pointer against the scale. This change in position would alter the rate of the clock and it would no longer be **synchronised** with the clock in the laboratory, making it impossible to measure as accurately as Einstein presumed the precise time the shutter opened and …

301 **Quantum Reality** (Einstein now at Princeton)
305 "The question that Einstein wanted to answer was: Does the inability to measure its exact position directly mean that the electron does not have a definite position? The Copenhagen interpretation answered that in the absence of a measurement to determine its position, **the electron has no position.**

{but dBB counters that , and dBB ≡ QM } SO **DOGMA**!
{Google: "In de Broglie–Bohm theory, nonlocality manifests as the fact that the velocity and acceleration of one particle depends on the instantaneous positions of all other particles."}

306… Instead, the two-particle thought experiment was constructed to show that such properties could have a definite simultaneous existence, that both the position and the momentum of a particle are 'elements of reality'.

308 while, an increasingly agitated Bohr realised that the argument Einstein had deployed was both ingenious and subtle. A refutation of the EPR paper would be harder than he first thought, …

310 …on 'disturbance' because he knew that it implied that an electron, for example, existed in a state that could be disturbed. Instead, Bohr now emphasised that any microphysical object being measured and the apparatus doing the measuring formed an indivisible whole – the 'phenomenon'. There simply was no room for a physical disturbance due to an act of measurement.

311 assumes that if particles A and B exert no physical force on each other, then whatever happens to one cannot 'disturb' the other. However, according to Bohr, since A and **B had once interacted** before travelling apart, **they were forever**

entwined as parts of a single system and could not be treated individually as two separate particles. {Einstein objected to Spooky action at a distance. Bohr knew "entanglement" but not its incredible future use} Later "Wheeler: no elementary phenomenon is a real phenomenon until it is an observed phenomenon. ‼

317 …theory'. A wave function that contains a living and a dead cat 'cannot be considered to describe a real state'. also 1935

320 '**It is basic for physics that one assumes a real world existing independently from any act of perception',** said Einstein. 'But this we do not know.'66 Einstein was a philosophical realist and { Quantum Mechanics is mainly a theory of **measurement**—how Nature interacts with instruments – **perception**—definition disagrees with Einstein. How Nature goes on its merry way without instruments is the domain of Einstein. We narrow the philosophy by having a given emitter and absorber and ask about the middle. Then , we care about Nature's mechanism to give known QM—no matter how strange or unanticipated it may be—e.g., wormholes connecting particles}.

321 as Heisenberg pointed out, 'we cannot escape the paradox of quantum theory, namely, the necessity of using the classical concepts'. It is the Bohr-Heisenberg call to retain classical concepts that Einstein called a 'tranquilizing philosophy'.

323 response. **Bohr's discovery that it was uranium-235 that underwent fission was far more important to the creation of the atom bomb than anything achieved by Einstein's two letters to Roosevelt.** The American government did not seriously begin thinking about developing an atomic bomb, codenamed the Manhattan Project, until October 1941.

326 'The necessity of conceiving of nature as an objective reality is said to be superannuated prejudice while the quantum theoreticians are vaunted', Einstein had once written to his old friend Maurice Solovine. '**Men are even more susceptible to suggestion than horses, and each period is dominated by a mood, with the result that most men fail to see the tyrant who rules over them**.'

Part 4, Does God Play Dice. Chapter 14, For whom Bell's theorem Tolls, p 331.

333 1951: Bohm Textbook and two papers to Phys Rev.
335 BELL: "**I saw the impossible done"** reference von Neumann's Foundations text against hidden variables -- he made a math mistake.
337 Molecules could be regarded as the unobserved microscopic 'hidden variable' that explained the observed macroscopic properties of gases. Einstein's explanation of Brownian motion in 1905 is an example where the 'hidden variable' is the molecules of the fluid in which the pollen grains are suspended.

Other Thoughts: {Article: "Conclusion. The tenet of the Copenhagen Interpretation that charged particles have no material existence until they are subjected to **measurement has no justification.** It is based upon the false notion that if a particle has a probability distribution then it does not have a material existence."… PLATO: … the Copenhagen interpretation. This may be true for people like Heisenberg. **But Bohr never talked about the collapse of** the wave packet. Nor did it make sense for him to do so because this would mean that one must understand the wave function as referring to something physically real…

The 1955 "Copenhagen Interpretation" was Heisenberg's – not Bohr's.

WIK: Quantum physics applies to individual objects. The probabilities computed by the Born rule do not require an ensemble or collection of "identically prepared" systems to understand.
is that there is no single, authoritative source that establishes what the interpretation is.

we can think of an electron as a wave or we can think of an electron as a particle, but we can not think of it as both at once. But in some sense the electron is both at once. Being able to think of these two viewpoints at once is in some sense being able to understand Quantum Mechanics.
Wheeler made a similar conclusion when he suggested that we should drop the word observer from our vocabulary, replacing it with the word **participator**.

Maudlin: "a physical theory should clearly and forthrightly address two fundamental questions: what there is, and what it does",
And then goes on to say that the Copenhagen interpretation does not address these questions.
QM interpretations survey n = 48: a mix of epistemological and ontic, 21% Bohr's view of QM is correct. 42% prefer Copenhagen. 58% said interpretation is very important. 50% said q foundations will still be discussed 50 years from now.

"The Reeh-Schlieder theorem of quantum field theory is sometimes seen as an analogue of quantum entanglement.

Page 341 Kindle: what Bohm offered Einstein was an interpretation that was 'nonlocal', requiring the instantaneous transmission of so-called 'quantum mechanical forces'. There were other horrors lurking in Bohm's alternative.
345 Bell then made an astonishing discovery. It was possible to decide between the predictions of quantum mechanics and **any local hidden variables theory** by measuring the correlations of pairs of electrons for a given setting of the spin detectors and then repeating the experiment with a different orientation.
locality. **Bell's theorem** said that no **local** hidden variables theory could reproduce the same set of correlations as quantum mechanics. And 1965-66 he shows von Neumann was wrong about hidden variables.

Experimental QM requires observation, and the observer is a participant. So talk of observer independent reality is irrelevant. So what happens without observers? Indeterminant!

353 that what really troubled Einstein was not dice-playing, but the Copenhagen interpretation's 'renunciation of the **representation of a reality thought of as independent of observation'.**
{for example, two oppositely moving electrons could be in a ± spin-x state that gets altered by actual experiment for spin z up or down. OR appropriate spins by pre-knowing what a future measurement will be – still non-local.
{another outside thought: **OR** initial travel then modified by contact with the observer with a separate but final re-travel. Initial existence and then later re-existence – exploratory trial and re-do if needed. Cosmic "Photons that Never End" have existence that doesn't get re-done Collapse is a hand-shaking agreement. } **Pseudo-Time** is reversible and reversed (back-and-forth) time before forced forward to our time. Ψtime is like another dimension keeping track of joint particles and enforcing laws of physics and conserved quantities.

356 When he was a student in the 1960s, John Clauser was often told that Einstein and Schrödinger 'had become senile' and their opinions on matters quantum could not be trusted. 'This gossip was repeated to me by a large number of well-known physicists from many different prestigious institutions',

358 …more difficult than just working out the equations', said Paul Dirac 50 years after the 1927 Solvay conference. The American Nobel laureate Murray Gell-Mann believes part of the reason was that '**Niels Bohr brain-washed a whole generation** of physicists into believing that the problem had been solved'.
359… **Roger Penrose.** 'I do not believe so. I would, myself, side strongly with Einstein in his belief in a submicroscopic reality, and with his conviction that present-day quantum mechanics is fundamentally incomplete.'

407 Bloch (1976), p. 320. In the original German: Gar Manches rechnet Erwin schon , Mit seiner Wellenfunktion. Nur wissen möcht' man gerne wohl, Was man sich dabei vorstell'n soll.
LAST p 449 back cover. Feb 4, 2021.

Previous: Comments on Rovelli's "Order of Time"

Dave 1/19/21

ROVELLI BOOK

The best way to describe the relative flow of time is the term "$dt/d\tau$" {dee t dee tau} for coordinate time intervals versus proper time intervals for three cases of interest:

1. Perceived **Psychological** time Δt versus Clock interval time $\Delta\tau$: perceived $dt/d\tau$ goes with the lack of significant events. You wake up in the morning and decide to sleep for a few more minutes and later notice that you clock time is an hour later. If you are in a scary situation, your time expands so that a few clock seconds feels like a prolonged time. Not much happening → dt short but hours have quickly passed → $dt/d\tau$ small. A lot happening → dt significant but little clock time has elapsed, $dt/d\tau$ big.
2. Relative **Speed**: the **Relativity** metric $c^2d\tau^2 = c^2dt^2 - dx^2$ says that if two events can be connected by a light line, $\Delta x = c\Delta t$, then the 4d-distance between them is **zero**. We have $(d\tau/dt)^2=1-(dx/dt)^2/c^2 = 1/\gamma^2$, so $dt= \gamma d\tau$. Observations of moving clocks {having dx/dt = v >0} sees expanded intervals of time duration. $\gamma \equiv (1-v^2/c^2)^{-1} \geq 1.0$.
3. **Gravity**: Weak field General Relativity when speed v ~ 0 has $c^2d\tau^2 = g_{oo}c^2dt^2$, $(d\tau/dt)^2= 1- 2GM/c^2r$, $dt/d\tau \simeq 1+(GM/r)/c^2$. So, a distant observer sees expanded coordinate time intervals of low-lying clocks in a gravitational potential.

Relativity teaches that there is no preferred frame of reference for laws of physics. But cosmology likes an ideal reference frame that moves along with the **cosmic flow** of the expanding universe (no CMB directed dipole in relative velocity red shifting). In general, gravitational fields and accelerations are weak; peculiar velocities are slow. All observers in the flow have about the same rate of time flow. NOW is a measured $z \simeq 1089$ for the cosmic black body background that defines a scale factor a = 1 for everyone. The expansion of the universe is a **universal clock for elapsed time** from the last scattering of light.

Thoughts and Comments Outside the Book:

Bias reality is tied to observations. Copenhagen Positivism

The universe is homogeneous (same laws of physics, same constants, same particles everywhere). Forms are templates in the vacuum of space-time. We know that when the temperature drops just right that recombination will occur everywhere at the same time era.

The Illusion of Time, **review** https://www.nature.com/articles/d41586-018-04558-7

"But I quibble with the details of some of Rovelli's pronouncements. For example, it is far from certain that space-time is quantized,… Ultimately, I'm not sure I buy Rovelli's ideas, about either loop quantum gravity or the thermal time hypothesis. And this book alone would not give a lay reader enough information to render judgment.

"The flow of time consists of the continuous creation of new moments, new *nows*, that accompany the creation of new space." [Muller, 2016 and the book "NOW"]. The future is being constantly created."

AND time-symmetry violation in B decay suggests that the direction of time might be set by something more fundamental."

The arrow of time with entropy is untestable and unfalsifiable.

subatomic particles called K and B mesons behave slightly differently depending on the direction of time."

Neutrinos and antineutrinos have some time asymmetry.

https://www.quantamagazine.org/how-axions-may-explain-times-arrow-20160107/

Wilczek 2016

… "A few years after Kobayashi and Maskawa's work, Gerard 't Hooft discovered a loophole in their explanation of T invariance. The sacred principles allow an additional kind of interaction. The possible new interaction is quite subtle, and 't Hooft's discovery was a big surprise to most theoretical physicists."

a laundry detergent named Axion had caught my eye. It occurred to me that "axion" sounded like the name of a particle and really ought to be one. So when I noticed a new particle that "cleaned up" a problem with an "axial" current, I saw my chance.

Axions, we calculate, should have been abundantly produced during the earliest moments of the Big Bang. If axions exist at all, then an axion fluid will pervade the universe. The origin of the axion fluid is very roughly similar to the origin of the famous cosmic microwave background (CMB) radiation,

[OTHER] the axion could solve one of physics' great mysteries: the excess of matter over antimatter, or why we're here at all… there are a few contradictions within the Standard Model, one of them being the imbalance between matter and antimatter.

neutrons have no charge. However, neutrons are made up of more elementary particles called quarks, which do have charges. So physicists expect neutrons to interact

with the electric field, But they don't. If the axion exists, it would turn off the interaction between the neutrons and the electric field, solving the strong CP problem.
suggest that through the interactions provided by the strong force and the weak force, the rotation of the axion creates just a tiny bit more matter than antimatter.
AND SEE https://arxiv.org/pdf/1910.02080.pdf Axiogenesis
"We propose a mechanism called axiogenesis where the cosmological excess of baryons over antibaryons is generated from the rotation of the QCD axion. The Peccei-Quinn (PQ) symmetry may be explicitly broken in the early universe, inducing the rotation of a PQ charged scalar field. The rotation corresponds to the asymmetry of the PQ charge, which is converted into the baryon asymmetry via QCD and electroweak sphaleron transitions."
Rovelli Page Captures: P24 HEAT "This is the ONLY basic law of physics that distinguishes the past from the future."
31 the cosmos begins in a state of low entropy, Entropy is due to Blurring
p 41 NOW means Nothing!
General (All same Forms) versus particular.
P 60 say 1400, "every city and village had a sundial" for Noon – continuous time zones. But 1900 had telegraph and a need for synchronizing clocks. Discrete time zones.
63 time is the measurement of change.
67 "absolute, true, and mathematical" time.
76 less time lower down? Means less Δt durations.
84 Granular Planck time
87 quantum superpositions of times – spacetime can be in a superposition of configurations.
89 HIS relational interpretation of quantum mechanics.
124 WdW has no time variable.

https://physicsworld.com/a/the-10-greatest-predictions-in-physics/
(have to register and sign in to see it – but it's worth it to see what's going on each week).
Quantum: Einstein, Bohr, and the Great Debate… (Hardcover)by Kumar, Manjit $44