Nagarjuna and Quantum Physics.

Eastern and Western Modes of Thought.

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Contents

Summary.

The key terms.

1. Key term: ‘Emptiness’. The Indian philosopher Nagarjuna (2nd century BC) is known in the history of Buddhism mainly by his keyword ‘sunyata’. This word is translated into English by the word ‘emptiness’. The translation and the traditional interpretations create the impression that Nagarjuna declares the objects as empty or illusionary or not real or not existing. What is the assertion and concrete statement made by this interpretation? That nothing can be found, that there is nothing, that nothing exists? Was Nagarjuna denying the external world? Did he wish to refute that which evidently is? Did he want to call into question the world in which we live? Did he wish to deny the presence of things that somehow arise? My first point is the refutation of this traditional translation and interpretation.

2. Key terms: ‘Dependence’ or ‘relational view’. My second point consists in a transcription of the keyword of ‘sunyata’ by the word ‘dependence’. This is something that Nagarjuna himself has done. Now Nagarjuna’s central view can be named ‘dependence of things’. Nagarjuna is not looking for a material or immaterial object which can be declared as a fundamental reality of this world. His fundamental reality is not an object. It is a relation between objects. This is a relational view of reality. Reality is without foundation. Or: Reality has the wide open space as foundation.

3. Key terms: ‘Arm in arm’. But Nagarjuna did not stop there. He was not content to repeat this discovery of relational reality. He went on one step further indicating that what is happening between two things. He gave indications to the space between two things. He realised that not the behaviour of bodies, but the behaviour of something between them may be essential for understanding the reality. This open space is not at all empty. It is full of energy. The open space is the middle between things. Things are going arm in arm. The middle might be considered as a force that bounds men to the world and it might be seen as well as a force of liberation. It might be seen as a bondage to the infinite space.

4. Key term: Philosophy. Nagarjuna, we are told, was a Buddhist philosopher. This statement is not wrong when we take the notion ‘philosophy’ in a deep sense as a love to wisdom, not as wisdom itself. Philosophy is a way to wisdom. Where this way has an end wisdom begins and philosophy is no more necessary. A.N. Whitehead gives philosophy the commission of descriptive generalization. We do not need necessarily a philosophical building of universal dimensions. Some steps of descriptive generalization might be enough in order to see and understand reality. There is another criterion of Nagarjuna’s philosophy. Not his keywords ‘sunyata’ and ‘pratityasamutpada’ but his 25 philosophical examples are the heart of his philosophy. His examples are images. They do not speak to rational and conceptual understanding. They speak to our eyes. Images, metaphors, allegories or symbolic examples have a freshness which rational ideas do not possess. Buddhist dharma and philosophy is a philosophy of allegories. This kind of philosophy is not completely new and unknown to European philosophy. Since Plato’s allegory of the cave it is already a little known. (Plato 424 – 348 BC) The German philosopher Hans Blumenberg has underlined the importance of metaphors in European philosophy.

5. Key terms: Quantum Physics. Why quantum physics? European modes of thought had no idea of the space between two things. They were bound to the ideas of substance or subject, two main metaphysical traditions of European philosophical history, two main principles. These substances and these subjects are two immaterial bodies which were considered by traditional European metaphysics as lying, as a sort of core, inside the objects or underlying the empirical reality of our world. The first European scientist who saw with his inner eye the forces between two things had been Michael Faraday (1791-1867). Faraday was an English scientist who contributed to the fields of electromagnetism. Later physicists like Albert Einstein, Niels Bohr, Erwin Schrödinger, Werner Heisenberg and others followed his view in modern physics. This is a fifth point of my work. I compare Nagarjuna with European scientific modes of thought for a better understanding of Asia. I do not compare Nagarjuna with European philosophers like Hegel, Heidegger, Wittgenstein.

The principles and metaphysical foundations of physical sciences are more representative for European modes of thought than the ideas of Hegel, Heidegger and Wittgenstein and they are more precise. And slowly we are beginning to understand these principles.

Let me take as an example the interpretation of quantum entanglement by the British mathematician Roger Penrose. Penrose discusses in the year of 2000 the experiences of quantum entanglement where light is separated over a distance of 100 kilometers and still remains connected in an unknown way. These are well known experiments in the last 30 years. Very strange for European modes of thought. The light should be either separated or connected. That is the expectation most European modes of thought tell us. Aristotle had been the first. Aristotle (384 - 322 BC) was a Greek philosopher, a student of Plato and a teacher of Alexander the Great. He told us: Either a situation exists or not. There is not a third possibility. Now listen to Roger Penrose:

“Quantum entanglement is a very strange type of thing. It is somewhere between objects being separate and being in communication with each other” (Roger Penrose, *The Large, the Small and the Human Mind,* Cambridge University Press. 2000 page 66). This sentence of Roger Penrose is a first step of a philosophical generalization in a Whiteheadian sense.

6. Key terms: ‘The metaphysical foundations of modern science’ had been examined particularly by three European and American philosophers: E. A. Burtt, A.N. Whitehead and Hans-Georg Gadamer, by Gadamer eminently in his late writings on Heraclitus and Parmenides. I try to follow the approaches of these philosophers of anti-substantialism. By ‘metaphysical foundations’ I do not understand transcendental ideas but simply the principles that are underlying sciences.

7. Key terms : ‘Complementarity’, ‘interactions’, ‘entanglements’. Since 1927 quantum physics has three key terms which give an indication to the fundamental physical reality: Complementarity, interactions and entanglement. These

three notions are akin to Nagarjuna’s relational view of reality. They are akin and they are very precise, so that Buddhism might learn something from these descriptions and quantum physicists might learn from Nagarjuna’s examples and views of reality. They might learn to do a first step in a philosophical generalisation of quantum physical experiments. All of us we might learn how objects are entangled or going arm in arm. [The end of the summary.]

2. Nagarjuna

Preliminary note

We should be cautious about hastily translating the Sanskrit terms ‘pratityasamutpada’ and ‘sunyata’ before having understood the full spectrum of their meaning. Rather than dealing with the abstract term ‘pratityasamutpada’ and sunyata’, this essay will work with the images which Nagarjuna used to illustrate his concepts. The images are evidences of relations, intervals and intermediate states. [1]

Nagarjuna's view of reality.

Nagarjuna was the most significant Buddhist philosopher of India. He was the founder of the Middle Way School, Madhyamaka, which is of great topical interest because it became fundamental to all later Buddhist scholarly thought, known as Mahayana (Great Vehicle). It is a path of inner liberation which avoids the extreme views of substantialism and subjectivism. Apart from various unconfirmed legends, we have no assured biographical knowledge of Nagarjuna. The authenticity of thirteen of his works has been more or less established by research. The Danish scholar Lindtner has examined and translated these works into English. Nagarjuna's main work, *Mulamadhyamaka-karika* (MMK) has been translated into several European languages [2] In the MMK the Middle Way is described as: “What arises dependently (pratityasamutpada) is pronounced to be substancelessness (sunyata). This is nothing but a dependent concept (prajnapti). Substancelessness (sunyata) constitutes the middle way”. [MMK: chapter 24, verse 18] Nagarjuna's view consists principally of two aspects. The first is an exposition of his view of reality (*sunyata*, *pratityasamutpada*), according to which reality has no firm core and does not consist of independent, substantial components. Reality is rather a system of two-bodies or many bodies which reciprocally affect each other [3]. This view of reality is

diametrically opposed to another key concept: '*svabhava'*, 'own being' or 'inherent existence', also known in the Greek tradition as 'substance'.

The second aspect of Nagarjuna's philosophy is an answer to the inner contradictions of four extreme modes of thought which can be subsumed under the headings: 'substantialism', 'subjectivism', 'holism' and 'instrumentalism'. My thesis is that these four modes of thought are unsustainable.

(1) Substantialism

Substance (or own being) is defined as something that has independent existence. [4] Substantialism is at the centre of traditional metaphysics, beginning with pre-Socratic philosophers, for example Parmenides and Heraclitus, who were two critics of substantial thought, and going right up to Immanuel Kant (1724-1804). Substance is considered to exist by itself, i.e. the unchangeable, eternal and underlying basis for the entire non-material foundation of the world in which we live. Plato (4th century BCE) made a distinction between two forms of being in his *Parmenides*: on the one hand, singular objects which exist exclusively through participation without own being and, on the other hand, ideas that do have own being. Traditional metaphysics adopted Plato's dualism. An independent own being is characterised as something that, as an existing thing is not dependent on anything else (Descartes); is existing by itself and subsisting through itself (More); is completely unlimited by others and free from any kind of foreign command (Spinoza); and exists of itself without anything else (Schelling). The highest substance was often understood as God.

Since Kant's 'Copernican Revolution' the primary question of philosophy has no longer been to comprehend reality, but rather to fathom the mind, i.e. the source of perception and knowledge.

For this reason traditional metaphysics has lost ground in the modern world. In fact its central concepts, such as 'substance', 'reality', 'essence' and 'being' have been replaced by the reductionist modes of thought of modern science. Now 'atoms',

‘elementary particles’, ‘energy’, ‘fields of force’ and other concepts derived from the ‘laws of nature’ are viewed as the fundamental ground.

(2) Subjectivism

Subjectivism is the philosophical theory that all knowledge is subjective, and relative. According to René Descartes (1596-1650) consciousness is primarily existent and everything else is sheer content or form, a creation of consciousness. The summit of subjectivism is the idealism of George Berkeley (1685-1753). The subjectivism of Immanuel Kant can be considered as moderated idealism. Hans-Georg Gadamer (1900-2002) emphasises that subjectivity i.e. self-awareness has become the fulcrum of modern philosophical thought which provides us with evidential proof and certainty. This view has been continually brought into doubt by modern physical science. However, these doubts have not led to a new view of reality but to a fatal separation of philosophy and the sciences. This separation has exacerbated the dualism that preoccupies modern thought. Accordingly, the physicist P.C.W. Davies, expounds in his 1986 book that electrons, photons or atoms do not exist; they are nothing but models of thought. [5]

(3) Holism

The third approach avoids the fatal either-or dichotomy of the first two approaches by merging subject and object into one entity, such that there are no longer any separate parts but only one identity: all is one. Holism is “the view that an organic or integrated whole has a reality independent of and greater than the sum of its parts”[6]. ‘Wholeness’ is made absolute, is mystified and becomes an independent unity that exists without dependence on its parts. Wholeness is understood as something concrete as if it was a matter of fact or an object of experience. As a philosophical approach found in great periods of European history of philosophy, this view is connected with names like Thomas Aquinas (1224-1274), Leibniz (1646-1716) and Schelling (1775-1854). In quantum

physics, holism is represented by David Bohm. His key concept is 'holomovement', an undivided wholeness in flowing movement. [7]

(4) Instrumentalism

Instead of favoring subject or object or the two together, the fourth approach ignores the existence of the three. According to this viewpoint the search for reality is insignificant and meaningless. Instrumentalism is quite modern, intelligent (see the philosophy of Ernst Cassierer) and sometimes hair-splitting and hypercritical. It is difficult to disengage from it. It is an extension of subjectivism and it regards the process of thinking as model making and as working with information, without concern as to what phenomena the information is about. What philosopher Donald Davidson (1917-2003) said about subjectivism, might be true for instrumentalism also: "Once one makes the decision for the Cartesian approach, it seems that one is unable to indicate what one's proofs are evidence for". [8]

For instrumentalism, theories are not a description of the world but an instrument for a systematic classification and explanation of observations, and for the prediction of facts.

The instrumentalist approach is outlined by the experimental physicist Anton Zeilinger who stated in an interview, "In classical physics we speak of a world of things that exists somewhere outside and we describe their nature. In quantum physics we have learned that we have to be very careful about this. Ultimately physical sciences are not sciences of nature but sciences of statements about nature. Nature in itself is always a construction of mind. Niels Bohr once put it like this: 'There is no world of quantum, there is only a quantum mechanical description'". [9]

Nagarjuna's viewpoint.

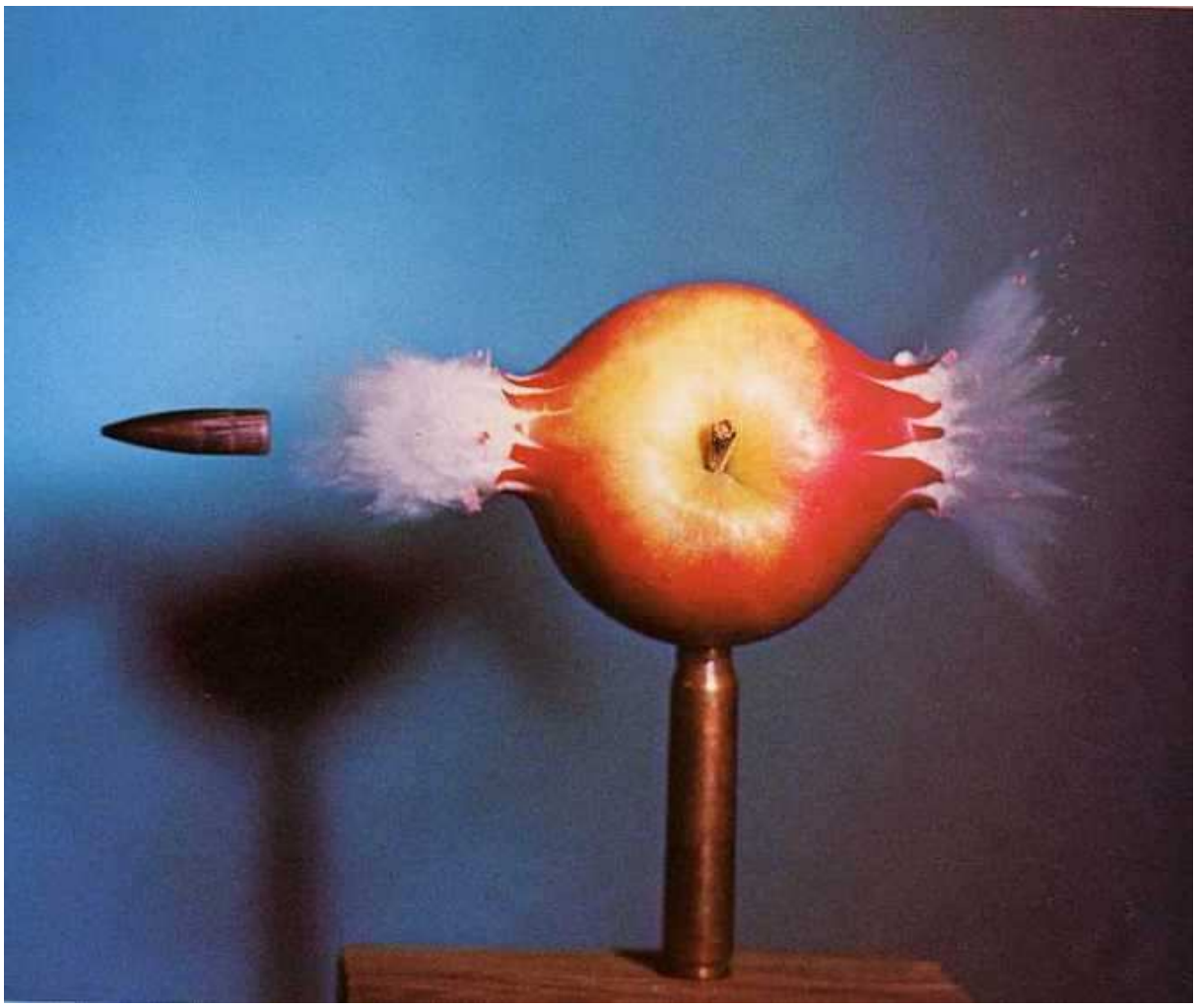
Nagarjuna presents these four extreme views of reality in a scheme that is called in Sanskrit: '*catuskoti'*, the equivalent of the Ancient Greek '*tetralemma',* as follows: *things have no substance: 1. neither out of themselves, 2. nor out of something else, 3. nor out of both, 4. nor without a cause.* (tetralemma: a figure in Ancient Greek and Eastern logic with four possibilities.) This kind of tetralemma refutes the four modern views of reality as above mentioned. This shows that Nagarjuna does not fall into any of these extremes and that his view is completely up-to-date. In the very first verse of the MMK a tetralemma is pointed out: "Neither from itself nor from another, nor from both, nor without a cause, does anything whatever anywhere arise". [10] This verse can be understood as the principal statement of the MMK: the refutation of the four extreme metaphysical views which cannot be reconciled with the dependent arising of things. If this is the case, the remainder of the MMK would be a clarification of this verse. This requires careful examination. What is the assertion made by this verse? That nothing can be found, that there is nothing, that nothing exists? Was Nagarjuna denying the external world? Did he wish to refute what evidently is? Did he want to call into question the world in which we live? Did he wish to deny the everywhere presence of things that somehow arise? If 'to arise' refers to the empirical data, then we are obliged to argue that if a thing does not arise out of itself, it must arise out of something else. So we should ask: what is the significance of the notion 'to arise'? In another text, Nagarjuna gives some indications how to understand this view. He writes in his *Yuktisastika* (YS): 19. "That which has arisen dependently on this and that *that* has not arisen substantially (svabhavatah). What has not arisen substantially, how can it literally (nama) be called 'arisen'? […] That which originates due to a cause and does not abide without (certain) conditions but disappears when the conditions are absent, how can it be understood as 'to exist'? [11]

By the notions of ‘to arise’ and ‘to exist’, Nagarjuna does not mean the empirical existence but the substantial existence, as we will see in the following examples. When in many passages of MMK Nagarjuna states that things do not arise (MMK 7.29), that they do not exist (MMK 3.7, 5.8, 14.6), that they are not to be found (MMK 2.25, 9.11), that they are not (MMK 15.10), that they are unreal (MMK 13.1), then clearly this has the meaning: things do not arise substantially. They do not exist out of themselves; their independence cannot be found. They are dependent and in this sense they are substantially unreal. Nagarjuna only rejects the idea of a substantial arising of things which bear an absolute and independent existence. He does not refute the empirical existence of things as explained in the following: “It exists implies grasping after eternity. It does not exist implies the philosophy of annihilation. Therefore, a discerning person should not decide on either existence or non-existence”. (MMK 15.10)

For Nagarjuna, the expression ‘to exist’ has the meaning of ‘to exist substantially’. His issue is not the empirical existence of things but the conception of a permanent thing i.e. the idea of an own being, without dependence on something else. Nagarjuna refutes the concept of independent existence which is unchangeable, eternal and existing by itself. Things do not arise out of themselves, they do not exist absolutely and are dependent. Their permanent being or existence cannot be found. The many interpretations of Nagarjuna which claim that he is also refuting the empirical existence of objects, are making an inadmissible generalization which moves Nagarjuna near to subjectivism, nihilism and instrumentalism. Such interpretations originate in metaphysical approaches which themselves have a difficulty in recognizing the empirical existence of the data presented. This is not at all the case with Nagarjuna. Nagarjuna presents the dependence of phenomena mainly in images as in the twenty-five chapters of the MMK.[12]

A brief review of the 25 chapters of the *Mulamadhyamaka-karika (MMK):*

1. A thing and its cause; 2. A mover and the distance to be moved; 3. A seer and a vision or view; 4. A cause and its effect; 5. A characteristic and its characterization; 6. Desire and the desirous one; 7. Origination, duration and decay; 8. Action and agent; 9. A viewer and a vision; 10. Fire and fuel; 11. Birth and death; 12. Suffering and the causes of suffering; 13. A teenager and an aged person; 14. Something and a different thing; 15. Being and nothing; 16. Bondage and liberation; 17. Action and its fruit ; 18. Identity and difference; 19. The past, the present and the future; 20. Cause and effect; 21. Coming to be and passing away; 22. The Buddha exists and the Buddha does not exist after death; 23. Pure and impure; 24. Buddha and bodhi; 25. Nirvana and being.



Chapter 1: Cause and effect. A high speed photograph by Harold E. Edgerton.

Picture: http://canibuk.wordpress.com/2011/11/16/harold-edgerton/

Commentary: A projectile after penetrating an apple. The penetration of the projectile is the cause of the direct effect: the beginning of an explosion of the apple. This happens at the same moment. Cause and effect cannot be separated. They are not one object and they are not two separated objects. There is no space and no time between cause and object. The cause leads immediately to a **near** effect. There is not first a cause and later an effect. The most important characteristic of bodies is their interdependence and the resultant, substancelessness, the impossibility of existing individually and independently. A thing is not independent of its cause and conditions, nor is it identical with them.

Chapter 2: A mover and the distance within which to move. Usain Bolt. 2012. Picture: Reuters. A thing is not independent of its conditions, nor is it identical with them. A mover does not exist without the distance within which to move. The mover and the distance are not one. A mover and the distance are neither together nor separated. The most important characteristic of bodies is their interdependence and the resultant, substancelessness, the impossibility of existing individually and independently.

Chapter 8. Action and agent. Picture: Allsport. Description: Cassius Clay (Muhammad Ali) lands a right on Brian London during their Heavyweight World Title Fight at Earls Court, London. Commentary: When there is no action there is no agent, neither exists *per se*. Action and agent are not isolated components; they arise only by their dependence on other bodies. Not the behaviour of bodies but the behaviour of something between them is essential.

Chapter 10: Fire and fuel. Photographer unknown. Commentary: Without fire there can be nothing designated as fuel. The material or immaterial components of a two-body or three-body system do not exist in isolation, they are not one and yet they are not independent of each other. Something is happening between these bodies and because of this, they are not substantially real. Nagarjuna emphasises one central idea: bodies are neither together nor separated. The most important characteristic of bodies is their interdependence and the resultant, substancelessness, the impossibility of an independent and individual existence.

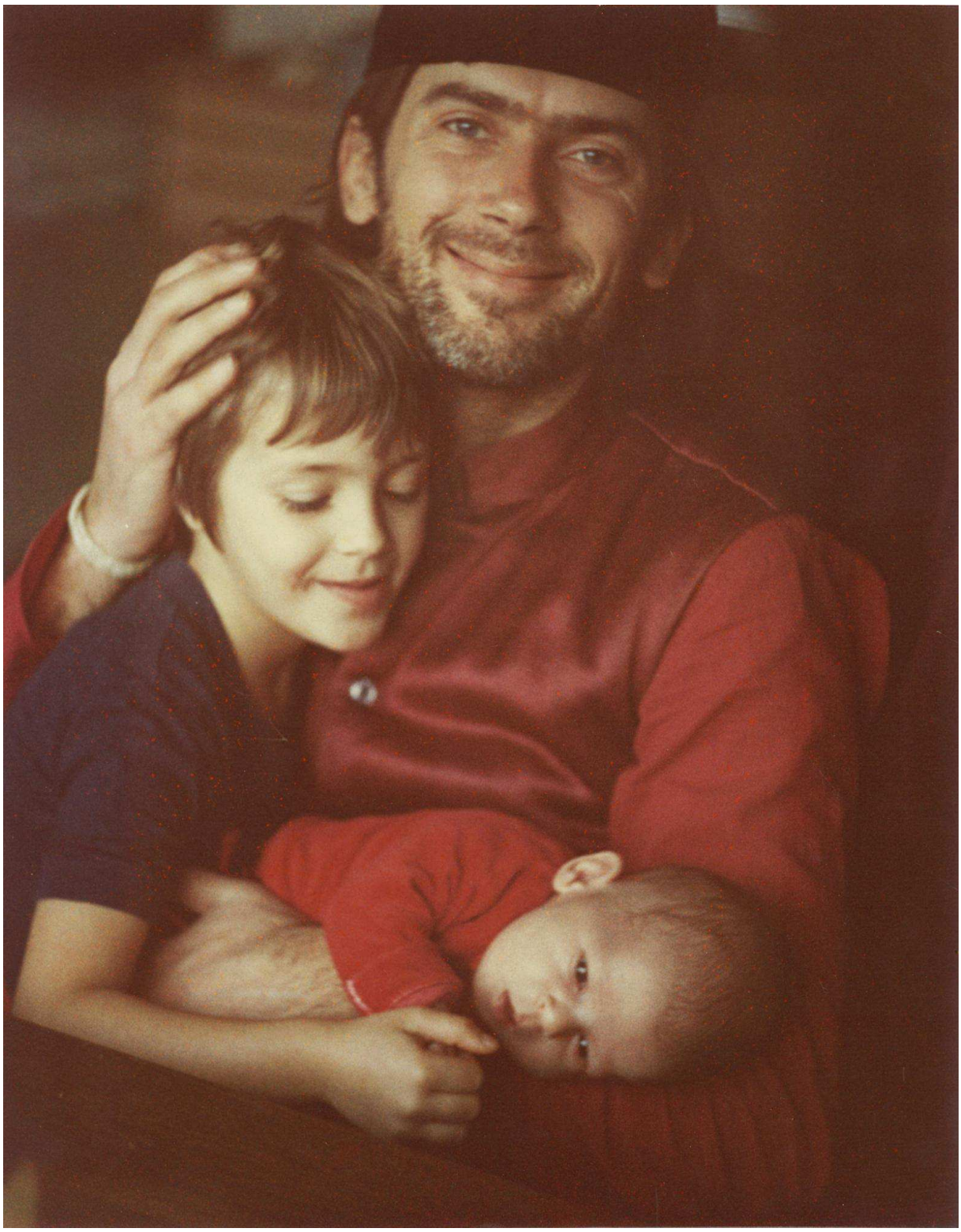
Chapter 12: Suffering and the causes of suffering. Picture: Kevin Carter. hunger1_kevin.carter. Commentary: Suffering is not independent from a cause of suffering and not identical with its cause. There can be no cause without an effect, or an effect without a cause. The notion ‘cause’ has no meaning without the notion ‘effect’. Cause and effect are not one, but they cannot be separated into two independent notions either. Like suffering reality does not consist of single, isolated material or immaterial components; suffering arises only by dependence on other causes. Like everything in this world suffering and its cause are not one and they are not two different objects.

Chapter 13. A teenager and an aged person. The 14th Dalai Lama, Tenzin Gyatso in exile in India. 14th of April 1959. Commentary: The Dalai Lama is not properly a teenager. He is a young man of 24 years. Picture: © Keystone Features/Getty Images. Next page: Photography by Wolfgang H. Wögerer, Vienna, Austria. Commentary: The 14th Dalai Lama in 2012 as a man of 77 years. These two men are not the same and they are not two different men.

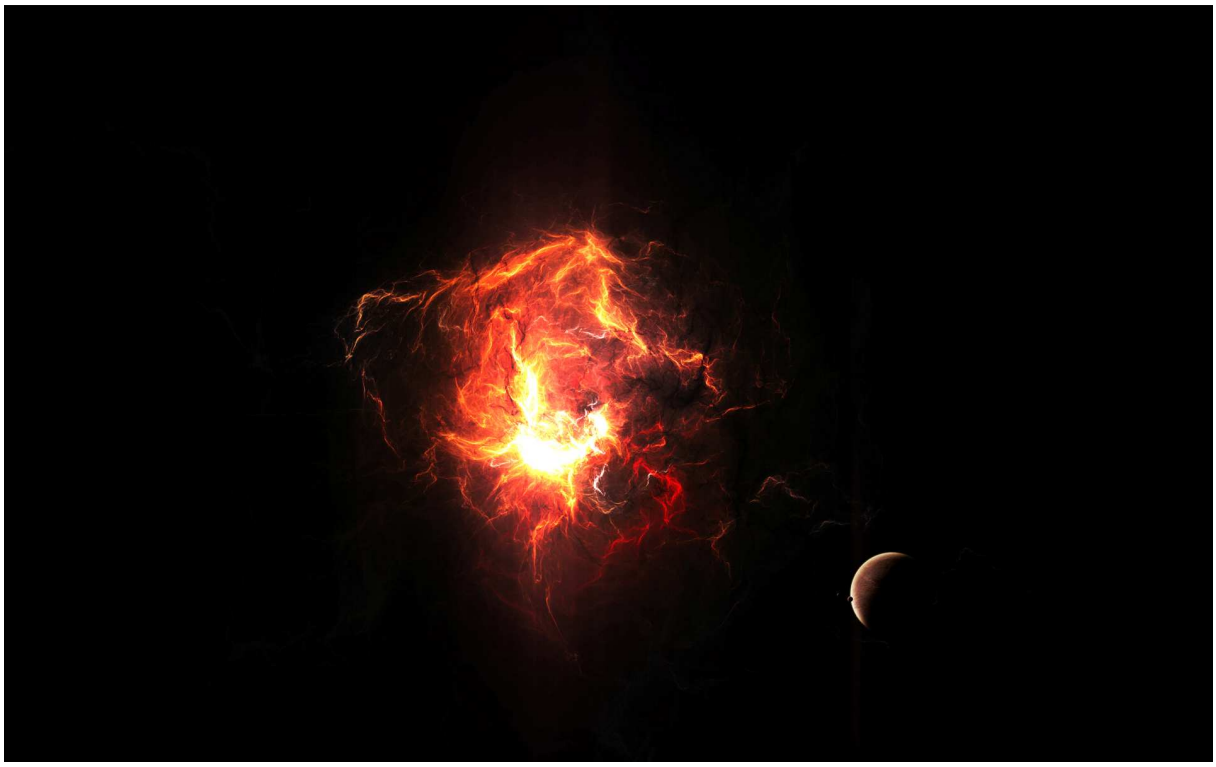
Chapter 13. A teenager and an aged person.

Chapter 16: Bondage and liberation. 1945. Description: Prisoners of Dachau, at liberation cheering the liberating US soldiers: We are free…free… Picture: http://isurvived.org/TOC-III.html . Commentary: There is no liberation without bondage. For two complementary realities, bondage and liberation, the nature and the existence of each are dependent on the other. There is no fundamental core to reality; rather reality consists of systems of interacting facts or ideas.

Chapter 23. Pure and impure. Rio Negro and the Amazon meet in Manaus, Brazil. Picture: Markus Mauthe. http://www.wildview.de/tag/rio-negro/. Commentary: Usually two waters get mixed when they come together. These two impure waters remain separated in the same river at the beginning of the Amazon. Only after 30 km they are completely mixed. The idea or notion ‘pure’ has no meaning without the opposite idea or notion ‘impure’. A fundamental or elementary or independent idea or notion does not exist. Our ideas or notions are dependent. One notion is contingent upon another.



Father and son. Description: The author, his daughter Larissa (left) and his son Nikolai (right), Dec. 1980. Picture: C.T. Kohl. “If the son is produced by the father, but the father also produced by that very son, then will you please tell me, which one is the true ‘cause’ and which the true ‘result’?” (Nagarjuna, *Vigrahavyavartani.)*



A solar storm. Something is happening between sun and earth. Picture: http://www.picalls.com/data/media/17/Solar_storm_1.jpg

3. Interpretation of MMK's 25 chapters.

In 25 out of 27 chapters, Nagarjuna emphasizes one central idea: bodies are neither together nor separated. The most important characteristic of bodies is their interdependence and the resultant, substancelessness, the impossibility of existing individually and independently. This is the meaning of *pratityasamutpada* and *sunyata*: bodies are without own being and are not independent of each other. Reality does not consist of single, isolated material or immaterial components. It is not the behaviour of independent bodies but the behaviour of something between them that is essential.

Let us concentrate on the 25 chapters: a thing is not independent of its conditions, nor is it identical with them. A mover does not exist without the distance within which to move. The mover and the distance are not one. A viewer is not the same as the view, but a viewer without a view does not exist. There can be no cause without an effect, or an effect without a cause. The notion 'cause' has no meaning without the notion 'effect'. Cause and effect are not one, but they cannot be separated into two independent notions either. Without a characteristic, we cannot speak of a characterization, and the other way round. How could there be a desirous one without desire? When there is no action there is no agent, neither exists *per se*. Without fire there can be nothing designated as fuel. The material or immaterial components of a two-body or three-body system do not exist in isolation, they are not one and yet they are not independent of each other. Something is happening between these bodies and because of this they are not substantially real. For two or sometimes three complementary bodies or for two concepts like cause and effect, or bondage and liberation, the nature and the existence of each are dependent on the other. The one arises with the other and disappears with the other. This is why a thing arises substantially, neither out of itself, nor out of another, nor out of both, nor without a cause. There is no fundamental core to reality; rather reality consists of systems of

interacting bodies. This view of reality is first and foremost an idea; a pointer to reality which cannot be described in words. One who can speak about concept-free reality has not experienced it. For the Buddhist tradition based on Nagarjuna, the yogic experience of substancelessness, the experience of dependent arising, the direct perception of reality as it is, all presuppose a high level of spiritual realisation which entails the abandonment of extreme views and the demolition of the entire edifice of dualistic thought and philosophy. To experience *pratityasamutpada* or *sunyata* means to become free of all entanglements of this world. *Nirvana* is simply another expression for this.

4. Discussion of Nagarjuna’s work.

For Nagarjuna, the primary question was not about mind, nor about the origin of knowledge but about the reality of the physical world. Tarab Tulku Rinpoche presented an all encompassing position when he said, “everything existing partakes in a fundamental 'mind-field', which is the basic 'substance' from which mind in a more individual way and the individual body develop”. [13] In order to emphasise that Nagarjuna does not only speak about views without substance but also about bodies without substance, here is a comparison with the views of reality suggested by quantum physicists. Physics is about views and the conditions of physical reality. It creates models and thus examines only realities which have been posited by physics itself. Nevertheless, as the experimental psychologist Irvin Rock who studied visual perception, describes it, we should not go so far as to consider all our perceptions and thought models to be purely adventitious. While the constructions of our mind are not identical with reality, they are not purely coincidental and usually not deceptive. [14] Behind these models are empirical bodies and there is some approximation of a structural similarity between a physical model and the corresponding physical and tangible reality.

5. The metaphysical foundations of quantum physics

"A courageous scientific imagination was needed to realize fully that not the behaviour of bodies, but the behaviour of something between them, that is, the field, may be essential for ordering and understanding events" [...] "What impresses our senses as matter is really a great concentration of energy into a comparatively small space" Albert Einstein.[15]

This is not a presentation or criticism of quantum physics but a discussion of the metaphysical mindsets and principles which underlie quantum physics. The views of reality in quantum physics can be expressed by three key terms: 'complementarity', 'four interactions' and 'entanglement'. [16]
In the prehistory of quantum physics it could not be proved experimentally whether the smallest elements of light were particles or waves. Many experiments argued in favor of one or the other assumption. Electrons and photons sometimes act like waves and sometimes like particles. This 'behaviour' was named: wave-particle dualism. The idea of dualism was therein understood to be a logical contradiction, in the sense that only one or the other could actually apply; but paradoxically both appeared.

According to this understanding of atomic theory, electrons and photons cannot be both particles and waves. According to atomic theory, a scientific explanation consists of a reduction of a variable factor into its permanent components and their applicable mathematical laws. This is the fundamental dualistic view that modern atomic theory has inherited from the natural philosophy of the ancient Greeks who expounded that substance and permanence cannot be found in objects of perception of the world in which we live, but can be found in the fundamental elements making up objects and their mathematical order. These material and immaterial foundations hold the world together, they do not change, although everything else changes. According to the expectation of atomic theory, it should be possible to reduce an

object to its *independent* elements, to its mathematical laws, or to its simple and fundamental principles. Until 1927 the fundamental elements had to be either particles or waves, they could not be both. What is to be understood by *independent* elements? As mentioned before, the notion of substance refers to something that has independent existence.

Albert Einstein's contribution to the interpretation of quantum physics

Albert Einstein was following the aforementioned metaphysical tradition when he wrote in the year of 1948 very clearly:

"For the classification of things that are introduced in physics, it is essential that these things have for a certain time an independent existence from each other, in so far as these things lie 'in different parts of space'. Without the assumption of such an independent existence [Einstein uses the German term So-sein, this is akin to terms like substance, or being, or suchness] of things which, in terms of ordinary thought, are spatially distant from each other, physical thought in the usual sense would not be possible". [17]

This idea of an independent reality was projected onto the basic element of the world of matter by atomic theory. For atomic theory, a scientific explanation means to reduce the variability and variety of objects and conditions to their permanent, stable, independent, and indivisible elements and to their conformity with mathematical laws. According to the expectations of atomic theory, all variations in nature can be explained in terms of separation, association and movements of unchanging, independent atoms or still more elementary particles. These particles and their conformity to mathematical laws constitute the core of bodies. They underlie everything and hold the world together. The question whether the fundamental

objects are waves or particles was an explosive issue: at stake were the traditional metaphysical views of reality available to quantum physics.

It became evident that fundamental reality could not be grasped by traditional views of reality. What is the explanatory value of atomic theory if it becomes clear that there are no independent, stable atoms or elementary particles, and that objects have no stable core? Are these quantum objects objective, subjective, both or neither? What is reality? Is the quantum world completely distinct from the world in which we live?

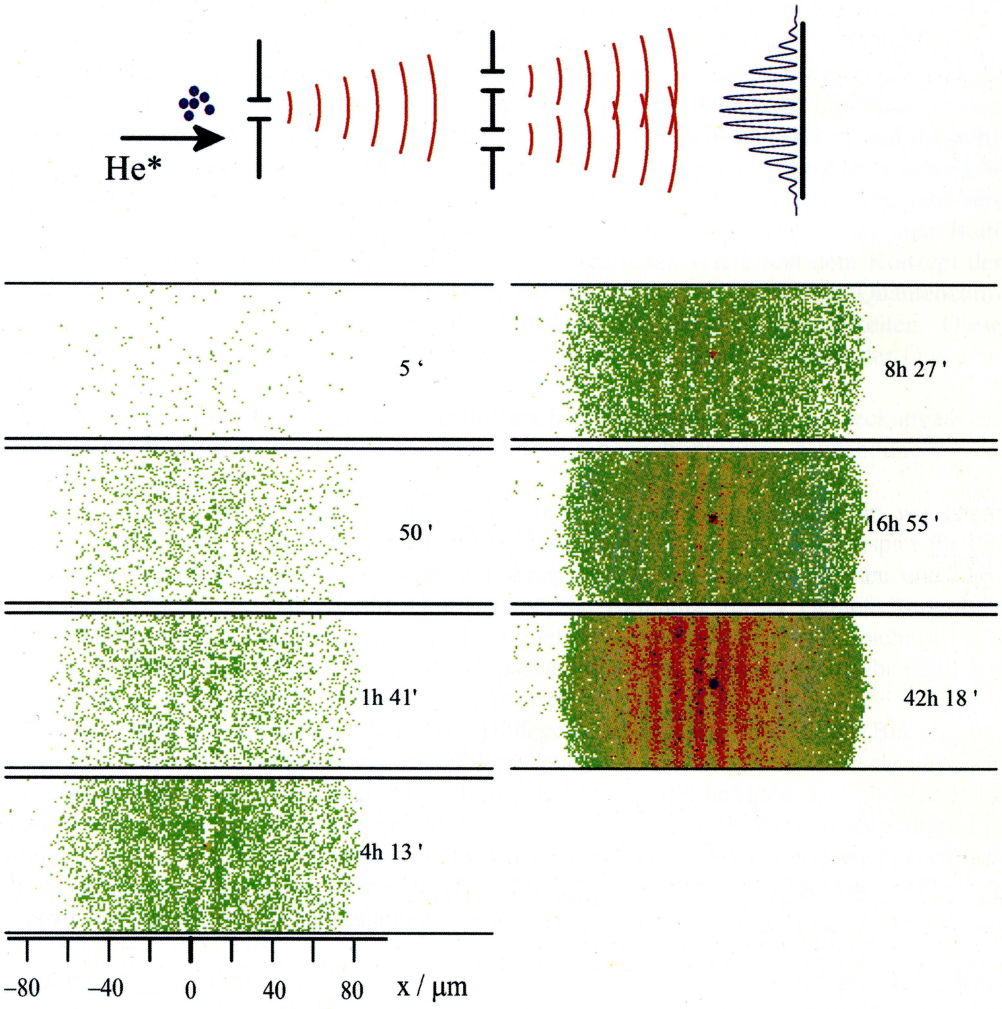
Niels Bohr's contribution to the interpretation of quantum physics

In 1927, the physicist Niels Bohr introduced the idea of complementarity into quantum physics. According to this idea, the wave form and the particle form are not two separate forms which contradict and exclude each other but are mutually complementary forms which can provide a complete description of physical manifestations only together. According to Niels Bohr, complementarity means that in the quantum world it is impossible to speak about independent quantum objects because they are in an interactive relationship with each other as well as with the instrument of measurement. He emphasized that this interaction between the quantum object and the instrument of measurement was an inseparable element of quantum objects, because it plays a major part in the development of several features of them. Certain measurements establish electrons or photons as particles and destroy the interference that distinguishes the object as a wave. Other measurements establish the object as a wave. This was Niels Bohr's new idea of reality.

From the insight that the quantum object and the instrument of measurement could not be separated, Niels Bohr did not conclude that there are no quantum objects. At least he did not do so when he was arguing in terms of physics. When

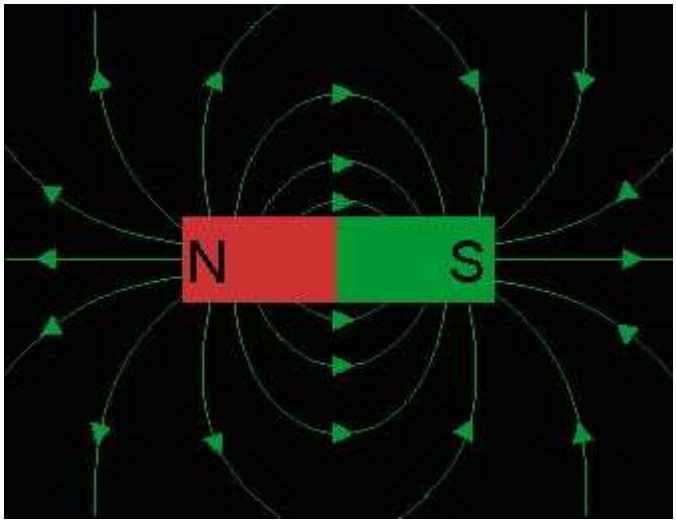
he spoke about the metaphysics of quantum physics he took an instrumentalist approach. [18] For the physicist Niels Bohr, quantum physical objects consist of interacting and complementary quantum objects.

Ein grundlegendes Experiment zur Quantenphysik:
Welle-Teilchen Dualismus der Materie



Schickt man Helium-Atome gleicher Richtung und Geschwindigkeit durch einen Doppelspalt, so erzeugt jedes Atom auf einem Schirm dahinter einen streng lokalisierten Auftreff*punkt*; das Helium-Atom erscheint hierbei seinem Wesen nach als ein Teilchen. Werden die Auftreffpunkte bei einem länger laufenden Experiment häufiger, so tritt ein Interferenzmuster in Analogie zum Youngschen Doppelspalt-Experiment auf. Die sieben Teilbilder wurden im Abstand von 5′ bis 42h 18′ nach Beginn des Experiments aufgenommen. Die Helium-Atome verhalten sich hier als Welle. Dieses Experiment stellt den Welle-Teilchen Dualismus der Materie in eindrucksvoller Weise dar. Wie es der Quantentheorie gelingt, den Widerspruch: punktförmiges Teilchen einerseits, ausgedehnte Welle andererseits zu überbrücken, wird in diesem Buch dargestellt. Diese Experimente mit Helium-Atomen wurden durchgeführt von Carnal, O., Mlynek, J.: Phys. Rev. Lett. *66*, 2689 (1991) und Kurtsiefer, Ch., Pfau, T., Mlynek, J.: Nature *386*, 150 (1997). Mehr dazu in Abschn. 6.6.

The double-slit experiment. (see previous page) If you send an atom of helium trough a double-slit, every atom produces a point behind the double-slit. The atoms arrive in discrete lumps. There is no interference in the beginning. The atoms arrive like bullets at the screen. But later they show interference. Their appearance shows the structure of waves in a similar manner to waves on water. The seven pictures shown were taken at intervals ranging from 5 minutes to 42 hours and 18 minutes. Quantum objects show a double quality of particles and of waves. They are dependent on the instrument of measurement: the double-slit. This double quality has been named 'complementarity' by Niels Bohr. Complementarity means that the two qualities are not dualistic. They do not exclude each other but complement each other like the poles of a dipole. Picture: Haken, H./ Wolf, H.C., *Atom- und Quantenphysik.* Springer Verlag Berlin 2000. With the permission of Springer Verlag.



Dipole. Picture: Quelle: leifi.physik.uni-muenchen.de/web_ph07_g8/umwe...

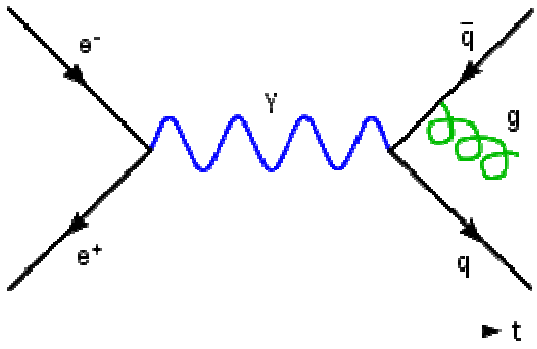


Figure 1: In this Feynman diagram, an electron and a positron annihilate each other, producing a photon (represented by the blue sine wave) that becomes a quark/anti-quark pair. The photon is or represents or creates or realises the electromagnetic interaction or electromagnetic force.
Picture: http://en.wikipedia.org/wiki/Feynman_diagram

The concepts of interactions in the standard model of quantum physics.

The notion of four elementary interactions was introduced in the standard model of quantum physics. These four forces obstruct the reduction of quantum objects into independent objects. Such an idea had already been posited by Democritus in the 3rd century BCE. The interactional forces which operate between the quantum objects, are added to the quantum objects. Instead of singular, independent objects, two-body systems or many-body systems were established as the base of matter. Between the bodies, interacting forces are effective in keeping them together. [19]
These interactions are a composite of the bodies. Mostly they are forces of attraction and in the case of electro-magnetic forces they can also be forces of repulsion. One visualises the interaction *between* the elementary particles as an interaction *of* elementary particles. The physicist Steven Weinberg puts it like this: “At the present moment the closest we can come to a unified view of nature is a description in terms of elementary particles and their mutual interactions. [...] The most familiar are gravitation and electromagnetism, which, because of their long range, are experienced in the everyday world. Gravity holds our feet on the ground and the planets in their orbits. Electromagnetic interactions of electrons and atomic nuclei are responsible for all the familiar chemical and physical properties of ordinary solids, liquids and gases. Next, both in range and familiarity, are the 'strong' interactions, which hold protons and neutrons together in the atomic nucleus. The strong forces are limited in range to about 10^{-13} centimeter and so are quite insignificant in ordinary life, or even in the scale (10^{-8} centimeter) of the atom. Least familiar are the 'weak' interactions. They are of such short range (less than 10^{-15} centimeter) and are so weak that they do not seem to play a role in holding anything together”. [20]

In this respect, the explanations enter into quite difficult and subtle particulars. How, for example, can an electron which consists only of one particle be in interaction with another quantum object? What part of itself can it emit if it consists only of one

particle? These questions can be answered by the concept of interaction. In fact an electron does not exist of only a single particle exactly because the interaction of the electron is a part of it. In 1978 The physicists Daniel Z. Freedman and Pieter van Nieuwenhuizen wrote in this regard that “the observed electron mass is the sum of the 'bare mass' and the 'self-energy' resulting from the interaction of the electron with its own electromagnetic field. Only the sum of the two terms is observable”. [21] What in quantum physics is known about interactions is here summarized in the words of the physicist and Nobel prize laureate Gerard 't Hooft: “An electron is surrounded by a cloud of virtual particles, which it continually emits and absorbs. This cloud does not consist of photons only, but also of pairs of charged particles, for example electrons and their anti-particles, the positrons. […] Even a quark is surrounded by a cloud of gluons and pairs of quark and anti-quark”. [22]

Singular, isolated, independent quarks, a phenomenon which is called ‘confinement’ in recent research, have never been observed. Quarks are captives, they cannot appear on their own but only as one of a pair or as one of a trio. When you try to separate two quarks by force, new quarks will appear between them which combine into pairs and trios. Claudio Rebbi and other physicists have reported that, “between the quarks and gluons inside an elementary particle, additional quarks and gluons are continuously formed and after a short time again subside”. [23] These clouds of virtual particles represent or produce interactions. The central core of quantum physics consists of a new view of reality that no longer perceives singular, independent elements but rather two-body systems, two states of a quantum object or two concepts, e.g., earth/moon, proton/electron, proton/neutron, quark/anti-quark, wave/measuring instrument, particle/measuring instrument, twin photons, super-positions, spin-up/spin-down, matter/anti-matter, elementary particle/field of force, law of nature/matter, etcetera. These systems cannot be separated into independent parts, or reduced to two separate, independent bodies or states, nor is one fundamental and the other derived, as the metaphysical either-or schemes of

substantialism and subjectivism try to establish. They are not joined into a seamless unity either, they are not the same, they are not identical and they are not a mysterious wholeness as holism indicates. Finally, we cannot claim, as instrumentalists do, that they are nothing but mathematical models which we have constructed and which do not correspond to physical reality. In physics, there is a fundamental reality that is not a one-body system. It is a two-body system or an assembly of bodies, a cloud of virtual particles which surround the central or 'naked' body. Between these bodies is an interaction that is one of the composites of them. This understanding of physics cannot be dislodged and yet all our metaphysical schemata struggle against it. The cloud does not conform to our traditional expectations of what should delineate and underpin stability, substantiality and order. How can clouds be what we are used to calling the basic elements of matter? How can this small vibrating something be what generations of philosophers and physicists have been searching for in order to arrive at the core of matter, the ultimate reality? Is this supposed to be it? From these little clouds we attempt to use metaphysical interpretation to distill something that has substance and is enduring. Entirely within the sense of the substance metaphysics of Plato, Heisenberg (1901-1976) contends that the mathematical forms are the idea of elementary particles and that the object of elementary particles corresponds with this mathematical idea. The physicist and philosopher Carl Friedrich von Weizsäcker (1912-2007) called mathematics 'the essence of nature'. According to the physicist Schopper, fields of force are the ultimate reality. [24] Some of us want to see reality as a mysterious whole (holism) or dismiss it as a construction without any correspondence to empirical reality (instrumentalism). All of this only because we do not find it easy to admit that the complex interactions of the world in which we live have their roots in a reality that is in itself complex.

It is impossible to escape from the entanglement of this world in quantum physics and, to find an elementary quantum object that is not dependent on other quantum

objects or on parts of itself. It is also impossible to dissolve the double-sided character of quantum objects. The fundamental reality of our physical world consists of clouds of interacting quantum objects.

6. Conclusion.

It seems that reality is not static, solid or independent and does not consist of singular, isolated material or immaterial factors, but of systems of dependent bodies. Most systems consist of more than two bodies, but there is no system that consists of less than two bodies. In quantum physics we call such fundamental two-body systems: earth/moon, electron/positron, quark/anti-quark, particle/field, etcetera. Nagarjuna calls his systems or dependent pairs: mover/distance to move within, fire/fuel, agent/action, viewer/view, etcetera.

Both, quantum physicists and Nagarjuna deal with two-body systems or two entities which have bodies that are neither properly separate, nor properly joined together. They do not unite into one, nor do they fall apart. These bodies are not independent and cannot be observed singly because in their very existence and constitution they are dependent on each other and cannot exist or function independently.

They are entangled by interactions, even at a far distance. One of them cannot be reduced to the other and it is not possible to explain one of them on the basis of the other. The resultant systems have a fragile stability, the components of which are maintained by interactions and mutual dependencies which are sometimes known, sometimes not fully known and sometimes totally unknown (for example as with entangled twin photons).

What is reality? We have become accustomed to believe in a firm ground under our feet and fleeting clouds above in the sky. The view of reality in Nagarjuna's thought and the ideas of complementarity, interactions and entanglement of quantum physics teach us that everything is built on sand. Moreover, even the grains of sand are not endowed with a solid nucleus. Their stability is based on balancing unstable interactions of their components.

Appendix 1.

Meanings of *pratityasamutpada*.

In the first place *pratityasamutpada* is an indication of dependence. Dependent bodies are in an intermediate state, they are not properly separated and they are not one entity. Secondly, they rely on each other and are influenced or determined by something else. Thirdly, their behaviour is influenced by something in-between, for example a mover is attracted by gravitational force, a viewer is dependent on rays of light between his eyes and the object, a piano player's action is determined by the fine motor skills of his fingers, an agent is dependent on his act. *Pratityasamutpada* is an indication of dependence and of something that happens between the objects. One object is bound to the other without being identical to it. The implicit interpretations of *pratityasamutpada*, are in terms of time, structure and space.

The following citations and references illustrate the term *pratityasamutpada*. *Pratityasamutpada* is used:

1. as Dependence in Nagarjuna's *Hymn to the Buddha:* " Dialecticians maintain that suffering is created by itself, created by (someone) else, created by both (or) without a cause, but You have stated that it is dependently born". [25]

2. as an intermediate state by Nagarjuna: Objects are neither together nor separated (Nagarjuna, MMK 6. 10).

3. as bondage in the *Hevajra Tantra:* "Men are bound by the bondage of existence and are liberated by understanding the nature of existence". [26]

4. as an intermediate state by Roger Penrose: "Quantum entanglement is a very strange type of thing. It is somewhere between objects being separate and being in communication with each other". [27]

5. as something between bodies by Albert Einstein: "A courageous scientific imagination was needed to realize fully that not the behaviour of bodies, but the behaviour of something between them, that is, the field, may be essential for ordering and understanding events". [28]

6. as the mean between things in modern mathematics: to quote Gioberti again: “The mean between two or more things, their juncture, union, transit, passage, crossing, interval, distance, bond and contact – all these are mysterious, for they are rooted in the continuum, in the infinite. The interval that runs between one idea and another, one thing and another, is infinite, and can only be surpassed by the creative act.

This is why the dynamic moment and dialectic concept of the mean are no less mysterious than those of the beginning and the end. The mean is a union of two diverse and opposite things in a unity. It is an essentially dialectic concept, and involves an apparent contradiction, namely, the identity of the one and the many, of the same and the diverse. This unity is simple and composite; it is unity and synthesis and harmony. It shares in two extremes without being one or the other. It is the continuum, and therefore the infinite. Now, the infinite identically uniting contraries, clarifies the nature of the interval. In motion, in time, in space, in concepts, the discrete is easy to grasp, because it is finite. The continuum and the interval are mysterious, because they are infinite”. [29]

Appendix 2.

What is quantum entanglement? Two very short answers:

According to Clegg:

“Entanglement is a strange feature of quantum physics, the science of the very small. It’s possible to link together two quantum particles — photons of light or atoms, for example — in a special way that makes them effectively two parts of the same entity. You can then separate them as far as you like, and a change in one is instantly reflected in the other. This odd, faster than light link, is a fundamental aspect of quantum science. Schrödinger, who came up with the name ‘entanglement’ called it ‘the characteristic trait of quantum mechanics’. Entanglement is fascinating in its own right, but what makes it really special are dramatic practical applications that have become apparent in the last few years”. [30]

According to Merali:

“This weird quantum effect inextricably links two or more objects in such a way that measurements carried out on one immediately change the properties of its partners, no matter how far apart they are. Quantum effects, such as entanglement, are usually confined to the invisible microscopic world and are detected only indirectly using precision instruments”. [31]

7. Notes

[1] See Appendix 1 for the term pratityasamutpada in Eastern and Western modes of thought.

[2] Lindtner, C. Nagarjuniana: Studies in the writings and philosophy of Nagarjuna. New Delhi: Motilal Banarsidass. 2002. It is worth noting, however, that Tilmann Vetter has raised doubts about the authenticity of one of Nagarjuna's works in: On the Authenticity of the Ratnavali. Asiatische Studien XLVI, 1992. pp. 492-506. For two well-known translations of MMK see: Kalupahana, D. J. Mulamadhyamakakarika Nagarjuna: The philosophy of the middle way. New Delhi: Motilal Banarsidass. 1999; Garfield, J. L. The fundamental wisdom of the middle way: Nagarjuna's 'Mulamadhyamakakarika'. New York: Oxford University Press. 1996.

[3] I use the expression 'body' synonymously with 'object' or 'particle' or 'field' or 'system' or 'entity'.

[4] Cf. Webster's New World Dictionary, Second College Edition, The World Publishing Company, New York and Cleveland. 1968. p. 669

[5] See: Gadamer, H.-G.. Der Anfang des Wissens. Phillip Reclam jun. Stuttgart 1999, p.35. Cf. Davies, P.C.W. and Brown, J.R. The Ghost in the Atom. Cambridge, University Press, 1986.

[6] Webster's New World Dictionary, Second College Edition, The World Publishing Company, New York and Cleveland. 1968.

[7] Cf. Bohm, D. Wholeness and the implicate Order. London: Routledge Classics. 2000.

[8] Cf. Davidson, D. The myth of the subjective. In: Davidson, D., Subjective, intersubjective, objective. New York: Oxford University Press. 1988 (my own translation from German).

[9] Zeilinger, A. Interview in the German newspaper Tagesspiegel 20th of December 1999 (my own translation). Steven Hawkings is defending a very similar position. He says: “I, on the other hand, am a positivist who believes that physical theories are just mathematical models we construct, and that it is meaningless to ask if they correspond to reality, just whether they predict observations”. Penrose, R. The Large, the Small and the Human Mind. In M. Longair (Ed.), The Objections of an Unashamed Reductionist. Cambridge: Cambridge University Press. 2000, p. 169. It is not meaningless to ask about the correspondence between a model and object, because if a model is correct then it has structural similarities with the phenomena that it is reconstructing; otherwise it can lead to predictions for which there are no meaningful physical explanation, because they have no correspondence to experimental data.

[10] Garfield, J. L. The fundamental wisdom of the middle way: Nagarjuna's 'Mulamadhyamakakarika' (MMK). New York: Oxford University Press. 1996, p. 3.

[11] See: Lindtner, C. op.cit., pp. 109 and 113.

[12] Images, metaphors, allegories or symbolic examples, analogical ideas, have a freshness which rational ideas do not possess. The starting point of the MMK is the double nature of phenomena. These fundamental two-body systems cannot be further divided analytically. The two bodies constitute a system of two material or immaterial components which complement each other. One of the components cannot exist without the other; each one forms the counterpart of the other.

[13] Tarab Tulku Rinpoche. UD-Newsletter N. 4, January 2006. Rabten, Geshe. Mahamudra. Der Weg zur Erkenntnis der Wirklichkeit. Le Mont Pélèrin. 2002. Keown, D.. A Dictionary of Buddhism. Oxford: Oxford University Press. 2003.

[14] See: Rock, I. Perception. New York: H.W. Freeman & Company. 1995.

[15] Einstein, A. & Infeld, L. The Evolution of Physics. London: Cambridge University Press. 1938. pp. 257, 311/312.

[16] The term entanglement is explained in the Appendix 2.

[17] Einstein, Albert. Quantenmechanik und Wirklichkeit, 'Dialectica 2', (my own translation). 1948. pp. 320-324. http://onlinelibrary.wiley.com/doi/10.1111/j.1746-8361.1948.tb00704.x/pdf.

[18] Niels Bohr says: “I do not know what quantum mechanic is. I think we are dealing with some mathematical methods which are adequate for description of our experiments” (Collected Works. Volume 6, Amsterdam: Elsevier Science Publishers. 1985, p. 103).

[19] “The most convenient context for investigating the forces of nature is a system of two objects bound together by mutual attraction. The earth and the moon, for example, constitute the most readyly accessible system in which to observe the gravitational force. The hydrogen atom, consisting of an electron and a proton, has long been an essential testing ground for theories of the electromagnetic force. The deuterion, made up of a proton and a neutron, represents a model system for studies of the forces in the atomic nucleus. Now there is a bound system in which to investigate the force that acts between quarks, the constituents of protons, neutrons and many related particles. The system is called quarkonium, and it consists of a heavy quark bound to an equally massive antiquark. The force at work in quarkonium is the strongest one known; it has come to be called the color force, and it is now thought to be the basis of all nuclear forces. Of the various two-body systems the simplest in some respects is the artificial atom called positronium” (Bloom, E. D. & Feldman, G. J. Quarkonium. Scientific American, 246, 5, 1982, pp. 42-53)

[20] Weinberg, S. Unified theories of elementary-particle interaction. Scientific American, 231, 1, 1974, pp. 50-59.

[21] Friedman, D. Z. & Nieuwenhuizen, P. van. Supergravity and the unification of the laws of physics. Scientific American, 238, 2, 1978, pp. 126-143.

[22] 'T Hooft, G. Symmetrien in der Physik der Elementarteilchen. In: Dosch, H. G. (Ed.): Teilchen, Felder und Symmetrien. Heidelberg: Spektrum. 1995, pp. 40-57 (my own translation).

[23] Rebbi, C. Frankfurter Allgemeine Zeitung. September 5th, 2001 (my own translation).

[24] Cf. Heisenberg, W. Der Teil und das Ganze, München 1969, p. 141. Weizsäcker, C.F. von Ein Blick auf Platon. Stuttgart: Philipp Reclam Junior. 1981, p.134. Schopper, H. Frankfurter Allgemeine Zeitung. May 5th, 1999.

[25] Nagarjuna, Catuhstava. Hymn to the Buddha. In: Lindtner, C. Nagarjuniana. New Delhi : Motilal Banarsidass. 1982. p. 135.

[26] Farrow, G.W. & Menon, I. The concealed Essence of the Hevajra Tantra. New Delhi: Motilal Banarsidass Publishers. 2001. p. 10.

[27] Penrose, R. The Large, the Small and the Human Mind. Cambridge: Cambridge University Press. 2000. p. 66.

[28] Einstein, A. & Infeld, L. The Evolution of Physics. London: Cambridge University Press. 1938, pp. 311-312.

[29] Gioberti, V. Della Protologia. Vol. 1. Náples: 1864, p. 160. In: Zellini, P. A brief History of Infinity. London: Penguin Books. 2005, p. 53.

[30] Clegg, B. The strange world of quantum entanglement. California Literary Review. March 20th, 2007. http://www.calitreview.com/51 accessed on October 2011.

[31] Merali, Z. Quantum effects brought to light: Results of entanglement made visible to human eyes. Naturenews. April 28th, 2011. Doi:10.1038/news.2011.252. http://www.nature.com/news/2011/110428/full/news.2011.252.html accessed on October 2011.

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9. Short CV of Christian Thomas Kohl. Christian Thomas Kohl is lecturer in history and philosophy of physical sciences at Tibet Institute, Rikon, Zurich (http://www.tibet-institut.ch). He has studied the history and philosophy of sciences at the Universities of Paris and Berlin and in 1973 he graduated in political science. He tries to follow the approaches of Edwin Arthur Burtt and Alfred North Whitehead. His core areas of research are the metaphysical foundations of quantum physics. He has also studied Indonesian and Indian music and was promoting music from India, Pakistan and China. Since the 1980s, he has been interested in the philosophy and history of Indian Buddhism. Since 1990 he has been working as a lecturer of history of sciences and languages in Switzerland and France. During the past three decades he has worked on 'reconciling' the fundamental principles of quantum physics and Buddhist philosophy. His home university is the University of Education, Freiburg (https://www.ph-freiburg.de). Email: kohl12345@gmail.com