REMARKS CONCERNING POSSIBLE RELATIONSHIPS BETWEEN SCIENCE AND BUDDHISM ON TWO LEVELS: I. FUNDAMENTAL PRINCIPLES, AND II. METHOD

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Both science and Buddhism are vast and irreducible systems which certainly have many differences. But at a fundamental level, there is a similarity in some of their goals, methods, and first principles. Indeed (i) one of the main goals of both of these systems is the research of truth; (ii) the result of this research is the discovery of a similar truth—the absence of absolute existence of all phenomena, called 'relativity' in science, and 'emptiness' in Buddhism—which in physics can be given the status of a first principle from which the various laws of nature can be derived; and (iii) the method used for discovering this truth is in both cases a penetrating view on the nature of reality.

I a.

HH the Dalaï Lama wrote:

> Spirituality and science are different but complementary ways of investigation. They have the same major goal: the research of truth. [...] Science, just like Buddhism, seeks to understand the nature of reality by means of a critical investigation. [...] We need both of them to relieve suffering on the physical as well as psychic level.[1]

The fundamental principles of Buddhism (emptiness) and of science (relativity) are also of a similar nature.

In science, relativity theories are those theories which have allowed us to reach the most comprehensive understanding of the physical reality. The principle of relativity states that no physical properties have any absolute existence. They are only relative to the system of coordinates chosen as reference points, and therefore they change when this reference system itself changes. In particular, these properties vanish in the proper reference system. Hence Galileo wrote four hundred years ago: "for all things that partake in it, motion is as if it

[1] SS Dalaï Lama, *Tout l'univers dans un atome. Science et bouddhisme, une invitation au dialogue*, Robert Laffont, 2006. (*The Universe in a Single Atom. The Convergence of Science and Spirituality*, Morgan Road Books, New York 2006).

were not, [...] motion is as nothing".[2] In other words, motion is not an intrinsic property of physical bodies, but a relative property *between* two bodies. As a consequence, we feel ourselves to be at rest while we are in motion with regards to other bodies: for example, whilst sitting in this conference hall, we consider ourselves to be at rest while in actuality we are turning with the Earth at 30 km/s around the Sun, 250 km/s around the centre of our Galaxy, etc. Therefore rest and motion, which seem to be antinomic properties, are in reality the same phenomenon seen from two different reference systems.

More than 2,500 years ago, the Buddha discovered the emptiness (*shunyata*) of all things, i.e. the absence of their intrinsic existence. The various phenomena are relative, never absolute—they appear through interdependent arising, and therefore do not exist independently. The *Prajnaparamita Hridaya Sutra* states that "form is empty, emptiness is form" [3] (where 'form' refers to the physical aggregate, i.e. matter in a general sense). In Buddhism, emptiness (of proper existence) is the very mode of being for all phenomena. It is remarkable that some of Nagarjuna's writings[4] from around 2,000 years ago anticipated Galileo's statements almost word for word: "motion, its beginning and its cessation are analogue to motion"; "the agent of motion, the motion and the place of motion do not exist [according to their proper nature]".

Since Galileo, the principle of relativity has been applied to position, orientation, and motion (including speed and acceleration in Einstein's theory),[5] and more recently to scales (of length, time, and mass), in the new theory of scale relativity.[6] As a consequence, physical quantities such as energy, momentum, angular momentum, etc., are entirely relative and cannot be defined in an absolute way. With Einstein's relativity theory, space, time, gravitation, and geometry itself can also be shown to be relative to the choice of the reference system. In 1907, Einstein realised that "someone moving in free fall in a gravity field does not feel any longer his own weight". In other

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2 Galileo Galilei, 1630, *Dialogo sopra i massimi sistemi*, Torino, 1975. (Translated from French : *Dialogue sur les deux grands systèmes du monde*, Ed. du Seuil).

3 The Dalai Lama. *Essence of the Heart Sutra: The Dalai Lama's Heart of Wisdom Teachings.* Boston Massachusetts: Wisdom Publications (2005).

4 Nagarjuna, in Kalupahana D.J. (trad.), *Nagarjuna: The Philosophy of the Middle Way*, State University Press of New York 1986.

5 Einstein A., *The Principle of Relativity,* Dover 1923, 1952.

6 Nottale L., 'Fractal Space-Time and Microphysics: Towards a Theory of Scale Relativity', *World Scientific*, Singapore, 1993. Nottale L., *Scale Relativity and Fractal Space-Time: A New Approach to Unifying Relativity and Quantum Mechanics*, Imperial College Press 2011.

words, in the coordinate system which accelerates with the fall (which is similar to the proper reference system of the falling body), the force of gravitation disappears. Moreover, in this free-fall system of reference, the parabolic geometric form of a trajectory seen from Earth, also disappears and becomes a point (relative rest), or a straight line (inertial free motion)—therefore 'form is empty'.

But there is more. We have known since Einstein's research that the laws of physics themselves—namely, the equations of transformation laws between coordinate systems and the equations of field and of motion in this field—can be derived from the principle of relativity itself. These laws emerge from the mere statement of the vanishing of the various physical quantities in the proper frame (emptiness). They are but manifestations of only the change in reference system (i.e. of making differences), without any need for any intrinsic 'substance': 'emptiness is form'. Therefore, the relativity-emptiness principle is not only a universal truth, but also a constructive principle from which the equations of physics can be derived.[7] For example, the equations of motion can be obtained by simply mathematically writing that there is no motion in the proper frame, followed by changing the reference. The entire complexity of the world then emerges from the mere multiplicity of all the relative states of reference systems.

There is no 'object', no 'subject', only relations. But, at a deeper level again, relations themselves can be shown to have no absolute existence. Consider an empty space in which there are only two bodies in relative motion, the distance between which increases with time. Each of the bodies considers itself to be at rest and the other to be moving, whilst actually there is only inter-motion, which is a relation, between them. But if one chooses to relate this apparent motion to a coordinate system which is itself expanding[8] (it is said to be 'co-moving'), this relative motion disappears in its turn. Another example is the definition of the position of a body. We need a reference point (the origin of the coordinate system) outside the body itself to specify its position. It is therefore given, not by a coordinate, but by a difference of coordinates, i.e. a length interval, which has the status of a relation between the two points (the reference point and the body). But this is not enough, since, in order to attribute a number to the distance of the body from the origin, we also need a unit. This unit is nothing other than another length interval between two other points, i.e. another

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7 *Ibid*.

8 See e.g. Weinberg S., *Gravitation and Cosmology*, John Wiley & Sons, New York, 1972.

relation. The final result of the measurement of the position of the body, for example 3.2 metres, means that the first length interval is 3.2 times longer than the unit. The numerical value 3.2 is the ratio of the two length intervals, and it is therefore a relation of relations. But if one attempts to measure the length of a body with respect to itself, this ratio is always 1, and the measure becomes empty of any information.

As we have seen in the previous examples, when we account for the relativity—not only of position, orientation and motion, but also of scale—we reach a new level of relativity theories, including the relativity-emptiness of relations. This new theory of scale relativity allows one to set the foundations of quantum laws on the principle of relativity itself.[9] In standard quantum mechanics, elementary particles still seem to own intrinsic mass, spin and charge. This seems to contradict with the Buddhist claim of the universality of emptiness. But, in scale relativity, the quantum laws can be derived from the geometry of space (generalised from curvature to fractality, i.e. explicit scale dependence), and the particles and their properties (mass, charge, etc.) emerge from the geometric properties of space-time itself (more specifically, of its geodesics, which are the mathematical lines which optimise the proper time). Elementary particles (which are also field and wave in quantum mechanics) have therefore only a relative existence and are no more than space-time. Their various properties are merely a result of the difference between their proper coordinate system and the system of reference given by the measurement apparatus, but there is no 'particle' in the place where we measure it. Maybe this supports the profound insight of the *Kalachakra tantra*, according to which the fundamental cause of the whole physical world would be 'particles of space', from which all other elements of the Universe take form.[10]

I b.

Another point, relevant to the theme of the present session (Understanding our Mind) concerns the analogy used for describing the nature of mind in Buddhism. It is said to be space-like, luminous

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[9] Nottale L., *Scale Relativity and Fractal Space-Time: A New Approach to Unifying Relativity and Quantum Mechanics*, Imperial College Press 2011.

[10] SS Dalaï Lama, *Tout l'univers dans un atome. Science et bouddhisme, une invitation au dialogue*, Robert Laffont, 2006. (*The Universe in a Single Atom. The Convergence of Science and Spirituality*, Morgan Road Books, New York 2006) *Tantra de Kalachakra, Le Livre du Corps Subtil*, Texte intégral traduit du sanskrit par Sofia Stril-Rever, Desclée de Brouwer 2000 (in French).

(aware), and radiating ('clear light'). These metaphors are actually taken from the physical world.

It may therefore be interesting to recall what physics says about the nature of light. Since Maxwell's discoveries, we have known that light is nothing more than a propagating electromagnetic field—specifically, electromagnetic waves. This understanding of the nature of light and electromagnetism is at the heart of many of the technologies of the modern world (radio, television, telephone, electric motors etc.). In the physical description, there is matter (masses, charges), and there are fields of force created by these masses and charges (gravitation, electromagnetism, etc.), and allowing their interactions. In quantum mechanics, both matter and fields are described in terms of elementary particles, but also in terms of different spin properties (this is an internal angular momentum). Due to these properties, matter particles (called fermions) cannot be in the same state, in particular, not in the same position. This is the basis of the observed organisation of matter (with its various solid, liquid, and gaseous phases, which correspond to the Buddhist 'elements'). Field particles (for example light photons), called bosons, have a tendency to aggregate, which is translated at macroscopic scales as being the radiating property. Therefore the luminous character (linked to the transport of information through interaction) and the radiating character of light are inseparable.

But what about the spatial aspect? Is light also space? These theories (the classical and quantum description of fields) are not yet complete, since they still describe an electromagnetic field *in* space, not yet as *being* space. In the evolution of ideas in physics, field theories have comprised three steps: (i) a description in terms of local forces; (ii) a description in terms of a space-filling field deriving from a potential; and finally (iii) a description in terms of space (more generally space-time) itself. In the case of the gravitational field, Einstein's theory has skipped to the final step. What was described by Newton as a gravitational force between two masses; by Laplace as a gravitational field created in all space by a mass, and given by a difference of potential; becomes in Einstein's theory a mere relative manifestation of the (curved) geometry of space-time.[11] The same is now true in modern relativity theory. In scale relativity, an electromagnetic field—and therefore light itself—has no proper existence, since it is understood as a manifestation of the fractal geometry of space-time at the microphysical level.[12] Finally, the space-

[11] Einstein A., *The Principle of Relativity*, Dover 1923, 1952.

[12] Nottale L., *Scale Relativity and Fractal Space-Time: A New Approach to Unifying*

like, luminous, and radiating characters of light are inseparable.

It may therefore be considered remarkable that the Buddhist description of mind and its functioning has known three similar steps: (i) mind functioning in terms of attraction-aversion-confusion (similar to the forces of attraction, repulsion, and diffusion in physics); (ii) mind as a potential of consciousness (not manifest), and a field of consciousness (in similarity with the physical field, which manifests itself only in terms of a difference of potential between two points but vanishes at a single point); and (iii) mind as space, from which all other aspects emerge (in similarity with the space-time description of relativity theories). The final step is the most profound one and fully accounts for the law of relativity-emptiness. This parallelism could be considered to support the universality of the relativity-emptiness principle, which applies both to matter (the aggregate of 'form' in the Buddhist description) and mind (the four other aggregates of sensations, perceptions, mental formations, and consciousnesses), and generates their structures and functions at the relative level.

II.

The second point to be discussed here is the question of the method, in both science and in Buddhism. One of the main practices of Buddhism is well-known—that of mind training and meditation (*shamata*: calm abiding through concentration without distraction, balancing attention and relaxation; and *vipasyana*: penetrating vision).

What is less well known is that the method used by great scientists such as Galileo, Newton, Poincaré, Einstein, etc. for making their discoveries, is also of a similar nature. Firstly, scientific research (as well as learning) always needs concentration. Secondly, in science, there is for the theoretician a large part of objective observation in the long term, followed by deduction (which is a linear process), and induction (which proceeds by extension and may reach larger territories). But grand changes of paradigm always result from intuition and have appeared as global *in-sights*. In these cases, it looks as if the scientists have skipped to the result by making a great mental leap, apparently completely separate from the basis of previously admitted knowledge. The truth often appears as a sudden realisation—a 'Eureka!' moment, as a global knowledge, beyond words; and then most of the time it is decades before we are able to 'materialise' the initial insight into the form of a detailed and efficient mathematical

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Relativity and Quantum Mechanics, Imperial College Press 2011.

theory. For example, it was twenty years from Newton's first understanding of universal gravity to the writing of the *Principia;* ten years from Einstein's fifteen-year old insight—according to which, if one follows an electromagnetic wave, i.e. light, time vanishes—to his 1905 construction of the theory of the special relativity of motion;[13] followed by another ten years to construct his generalised theory of relativity,[14] etc.

Why is this so? If a scientific discovery in physics was the result of a mental construction or of imagination, this would be impossible, because the number of imaginary constructions is infinite, while the actual laws to be found are those of a unique world. The answer may be that, as some of these great scientists have described, their discoveries were the result of an interior vision, of a penetrating view about the nature of reality. This can occur only by looking into our own minds, rather than looking only at the exterior—which yields the problem to be solved, but not the solution, which comes from the interior. Let us suggest two analogies for this process. It is like trying to see something veiled by fog: when the fog dissipates, the landscape appears immediately and in its entirety, without having to build each of its elements. Another analogy would be of someone trying to find their way in an unknown jungle. It is impossible—everything is obscured by vegetation. But by climbing to the top of a mountain, the whole jungle appears clearly, with its rivers, lakes, rocks, clearings, etc. After descending the mountain again, whilst still nothing is locally seen, one is now able to make a map, or guide people and say "the lake is to the right, the river just beyond these trees, etc."

In other words, this demonstrates that the truth is already there, and does not have to be constructed or reconstructed. The work does not need to be done on truth, but on ignorance. This is clear from the expressions 'dis-cover', 'un-veil', which are used for qualifying fundamental discoveries (as opposed to the term 'inventions', which refer to technological progressions). In these cases, the truth was covered by mental obscurity, so that the method of 'discovery' consists of being able to see through this obscurity in order to let the truth shine and to make it appear clearly. This involves practising meditation and mind training.

Let us conclude with the question of education. What is true for research scientists is also true for students, at all levels of education. The aim of teaching is to transmit knowledge. Profound knowledge, in

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[13] Einstein A., *The Principle of Relativity* Dover, 1923, 1952.
[14] *Ibid*.

Buddhism as in science, has often been acquired through many generations of very hard and long work, and, fortunately, it can be transmitted in a faster way. But the student must re-discover the truth, on his own if he does not want his knowledge to be superficial. Even though it is faster, this process of re-discovery is of the same nature as the discovery. Namely, there too, the method consists of dissipating the obscurities, the limitations and the ignorance which are obstacles to the truth in the student's mind. A genuine, profound, and stable understanding can be reached, provided that the student also experiences the joyful and enthusiastic experience of insight, the 'Eureka!' moments through which everything becomes clear and luminous. Therefore, it seems to me that the practice of meditation and mind training in order to develop good qualities should be a fundamental part of any educational project. Let us finally give the last word to Nagarjuna: "When the idea of I and mine is destructed relatively to the internal and the external, appropriation comes to an end, and with its destruction, […] the liberation occurs…"[15]

[15] Nagarjuna, in Kalupahana D.J. (trad.), *Nagarjuna: The Philosophy of the Middle Way*, State University Press of New York 1986.