Space Time and Maps

Tamara Bellone and Luigi Mussio

Abstract Concepts of space and time were important for man, at various levels, for philosophy, science and religion. Astronomy, Philosophy, Mathematics, Physics, Geography and Cartography were most involved topics. Actually, shape and history of Universe, and specially of Earth, are related to their representation: so, ideas about space and time have largely coped with survey and mapping, from Geodesy to Geomatics.

Keywords Space · Time · Maps · History of science

1 Introduction

Concepts of space and time have always been important to man, at different levels, for everyday life, for philosophy, science and religion. The perspective here relates more closely to European science, while acknowledging the independent development of science in Middle, South and Far East. Partition of time and space is somewhat different in different ages and cultures (Chinese, Indian, Arabic/Persian, etc.). As for space, for instance, Darwin (Odifreddi 2010) used a certain number of particular homogeneous areas:

- Asia, Europe, Mediterranean Africa and North America;
- Latin America, which ends with the desert highlands of present United States;
- Sub-Saharan Africa;
- Madagascar;
- Australia, New Guinea and New Zealand.

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Indeed all cultures define time and space around them, by a imposition of a specific order (physical, mental and cultural). The following is a short history of the evolution of the concepts of space and time in Western culture, from the myths to the scientific concepts. A sense-based conception of space and time defines, that space recognizes the physical extension and it's the main object of measurement, calculation and analysis of surveying and mapping disciplines; however the notion, that time flows in one direction is merely a property of human consciousness.

Astronomy, Philosophy, Mathematics, Physics, Geography and Cartography are the subjects most involved. Indeed the shape and history of the Universe, and especially of the Earth, relate to how these have been represented. Thus ideas about space and time largely dealt with survey and mapping, from Geodesy to Geomatics. Understanding space involves two human operations, different but closely related, vision and handling. They let classify spaces and objects:

- objects, that may stay in hands;
- objects, that may be seen just moving the head;
- objects, that may be seen just walking around them;
- object, contained in a space, which may be visited by a simple walk;
- the same as above, to be recognized by more trips;
- Earth space;
- Universe space.

The first object of this classification has specific Cartesian orthogonal characteristics. Exactly by extension, the same Cartesian characteristics are attributed also to the second and third objects. On the contrary, starting from the fourth object, an important feature is the spherical form, relative to the observer's vision, which separates into a flat projection of the image and in a measure of the spherical distance. Thus according to Husserl, due to axis rotation, where distance becomes altitude and, due to curvature inversion, where a concave form becomes a convex one, recognizing the spherical form of the Earth.

Plant and animal behaviours are referred to space and time (and also number), e.g. vertical direction, season sensitivity, etc. Human behaviours extend, but not contradict their original physical nature. Animals have a kind of intuitive sense-based knowledge of physics, registered in the brain as a result of natural selection. Some animals are able to estimate quantities and to count to four. Thus shaping a branch to get a stick, in order to measure the depth of a river, is in any case an example of an elementary Geomatics procedure. The ability to represent themselves by the mind, in the past and in the futures, is a mental time travel. Cognitive scientists haven't yet determined whether this capacity belongs to animals. Anyway, there are neurons in the brain of some animals selectively sensitive to the number of objects, regardless of their size, shape or location (generally only until four).

However only the human being, through language, is able to apply grammar and syntax to the phrases and consequently to the numbers by the so-called recursively rules. For these reasons, the Kantian a priori form intuition includes the number and the capability to measure. Therefore according to Chomsky (Chomsky et al. 2002), two a priori forms: broad and narrow, are the unique human component of the linguistic faculty:

- the Linguistic Faculty: broad, includes a sensory motor system, a conceptual intentional system and the computational mechanisms for recursion;
- the Linguistic Faculty: narrow, based on the computational mechanisms for recursion, provides the capacity to generate an infinite range of expressions from a finite set of elements (Figs. 1 and 2).

Darwin conducted experiments on plants and animals, which still today affect the research:

- plants are aware of gravity and they can distinguish up from down;
- plants to survive must know the direction of the surrounding light;
- plants don't measure the length of the day, but that of the continuous period of darkness;
- a common structure for time, space and number exists in the brain of animals and humans;

Fig. 1 Chimpanzee preparing a stick (from it.dreamstime.com)

Fig. 2 Orangutan measuring the depth of a ford (from ViralSpell.com)

- an animal evaluates how many trips it is necessary to make to obtain a finite supply of food.

2 The Thought of the Ancient Greeks

Many ancient cultures believed that the Universe was developed from the centre of the Earth, which holds together the Universe. The axis of the world establishes an order in the cosmos, but the problem, is that really the axes are two: the first axis, materialized by the feeling of gravity, connects the zenith, the location on the Earth and the nadir: this axis divides the space into three parts: Earth, Heaven and Underworld, and it's symbolized by the human being himself and by a sword; the second axis is the polar axis: this axis is indicated by a whirlpool, a mill or a round walk of an animal.

Many ancient rites provided for the alignment of the axis of gravity with the polar axis, and the ancients feared, that would return chaos, if the centre of the Earth had collapsed. For these reasons, from the beginning human beings have felt the need of a reference system (De Santillana et al. 2011).

The Greeks travelled in the Mediterranean Sea (e.g., Argonauts, Ulysses and circumnavigation of Africa by Phoenicians), approaching new concepts of space and time. Therefore geographical data, represented in maps, are acquired according to celestial and terrestrial measurements; nevertheless numbers, weights and measurements became much more important since Middle age, thanks to contributions of Indian, Persian and Arabs.

Going deeply at the origin of Western scientific thought, Cartography from the beginning has two aspects: it's the representation of the entire world, in the broadest sense, but it's often a representation of a certain territory, for immediate purposes. Indeed, Greek Geography is related to Cosmology rather than to practical purposes. Anaximander (Rovelli 2014) believed, that everything derives from a primordial substance, in which everything dissolves later (the contemporary philosopher Popper believes, that Anaximander was at the origin of scientific thought).

According to Anaximander and his Greek followers, time is derived by a cyclical conception and space is homogeneous, so that the Earth is floating in space, without falling, without the need to lean on something. There aren't absolute directions, so things don't fall to an absolute low (a direction that is the same everywhere in the universe). However the things fall to Earth and the very meaning of high and low becomes ambiguous.

Successively the concepts of space and time develop largely in the thought of ancient Greeks (Abbagnano 1982a, Vol.1). The Greeks, in particular the Pythagoreans and Aristotle, founded it difficult to conceive of the nothing and the non-being. Thus space is occupied by the objects, which it contains; however in Indian thought the idea of zero, the possibility of nothingness and the empty space are present from early times. As said above, time is mostly cyclical; indeed the Earth's rotation around its axis determines the alternation of days and nights, and its rotation, around the sun in the ecliptic, determines the changing of the seasons.

Plato and Aristotle believed the cosmos to be a finite amount of spherical form, because only the sphere is perfect. In Aristotelian cosmology, in turn, also accepted by Ptolemy, the idea of space itself doesn't change, because only individual substances exists, of which space is the premise. On the other hand, the classical Greek thought wasn't so uniform as one may think; indeed among Pythagoras' pupils, for example, there were different opinions about the possible finiteness of the Cosmos. Also the exclusion of the void wasn't so general; indeed for Democritus and Epicurus atoms move in an empty space.

Furthermore Democritus realized, that the matter can't be a continuum. Indeed if an object is continuously divided, in the end, points without extension are obtained, but putting together these un-extended points, it would be impossible to remake the object. The alternative is to assume, that any piece of matter is made up of a finite number of discrete indivisible particles, called atoms. According to Democritus, the space became the container of the world, whose constituent elements are the same for all beings. It's an immense space, undifferentiated and absolute, the space which will be found again in the physics of Newton. Therefore Greek geometry doesn't directly affect the space, but the shape of things that fill it. These forms are considered independently of the objects, which can be assigned.

Moreover since any object of the world perceived by the senses can have the perfect forms of geometry, these can only exist as ideas. Plato's ideas are original essences, the prototype of all the sensible things. These are generated by a demiurge in the image and likeness of those ideals, which are perfect, eternal and immutable.

After Alexander's death, his empire was divided and his general Ptolemy I chose Alexandria as the capital, where he began the construction of the legendary library. Just in Alexandria, the mathematician and philosopher Eratosthenes calculated the radius of the Earth and founded the mathematical geography, where Hipparchus invented America, due to different tides in two oceans and Ptolemy drew the map of the known Earth.

For Aristotle the spheres, made of ether, rotate materially, with the planets fixed on them, but Ptolemy had an abstract perspective, as a mathematician, so that the spheres aren't real nor material. Aristotle and Ptolemy said, that a state of rest is the most favourable and the Earth doesn't move; in contrast, in modern times, both Galilei and Newton were interested to the motion of bodies. Going against the geocentric favoured configuration Aristarchus of Samos and Archimedes proposed an innovative heliocentric configuration, as Persian astronomers in the Middle Ages and Copernicus in the Renaissance would do (Figs. 3 and 4).

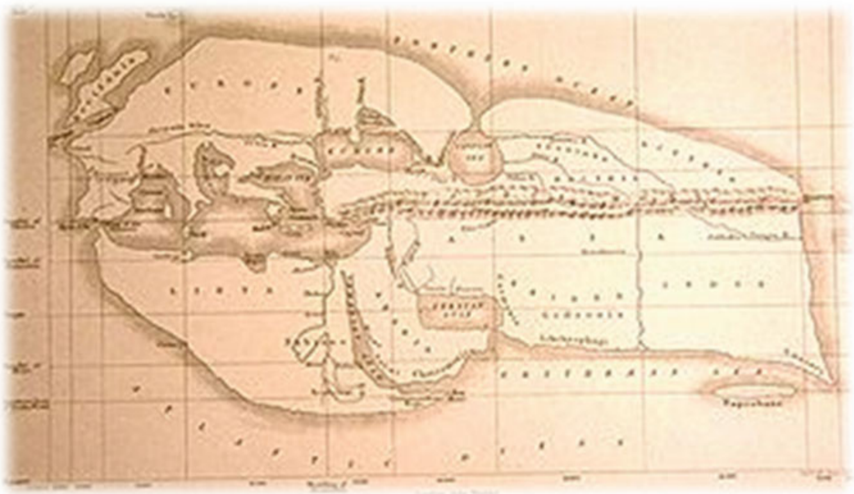


Fig. 3 Eratosthenes' map (from Wikipedia)

Fig. 4 Ptolemy's map (from Ancientcoinsforeducation.org)

3 From Middle Age to the Renaissance

As for time, Greeks saw it as cyclical and absolute; in contrast, in modern times, it will be linear and absolute (according to Newton), or linear and relative (according to Einstein). Quite the opposite was Augustine of Hippo's view, who stated, that time is related to physical perception, as it's in Leibnitz, Herbart, Gestalt theory and Psychoanalysis. Indeed in the Middle Age, time was created by God with the universe, but its nature remained deeply mysterious.

Augustine criticized Aristotle's conception of time as a measure of motion of stars and stated, that time was a stretching of the soul (distentio animi), so that time lost its absolute meaning, becoming interior time. The subject, while living only in the present, is aware of the past thanks to the memory and of the future by virtue of waiting.

From Augustine on, Christian thinking conceived the time as linear-progressive and not cyclical-circular as in the ancient world.

Travels, from Renaissance to XVIII century and over, stimulated production of maps and related instruments, finding that correct geographical coordinates are essential at sea. While fixing latitude was comparatively easy, the problem of longitude required a good timepiece; availability of accurate watches and good lenses depended on the alliance of science and technology, founding the Nova Scientia of the modern times (it's perhaps no coincidence, that Spinoza himself was a lens-maker). Renaissance went over certain limits of the Middle age:

- a copy of Lucretius' De Rerum Natura was found;
- the Elements of Euclid and the Geography of Ptolemy were translated into Latin from Greek, becoming accessible to European scholars;
- Erasmus of Rotterdam published the Encomium Moriae and Thomas More his Utopia;
- the claim of Reform favoured an increment of the economic development in Netherlands and England, and promoted the production of new maps.

For these reasons, the concept of space as an entity in itself derives from the Renaissance. It would be a symbolic form, in the sense given by the neo-Kantian Cassirer. The T-O maps expressed a Christian imago mundi (Fig. 5), but were not a realistic description of the world. (Brotton 2013). Nevertheless, it was medieval minds which invented perspective (Fig. 6), dispensing with religious reference. Just

Fig. 5 An example of TO map (from Pinterest.com)

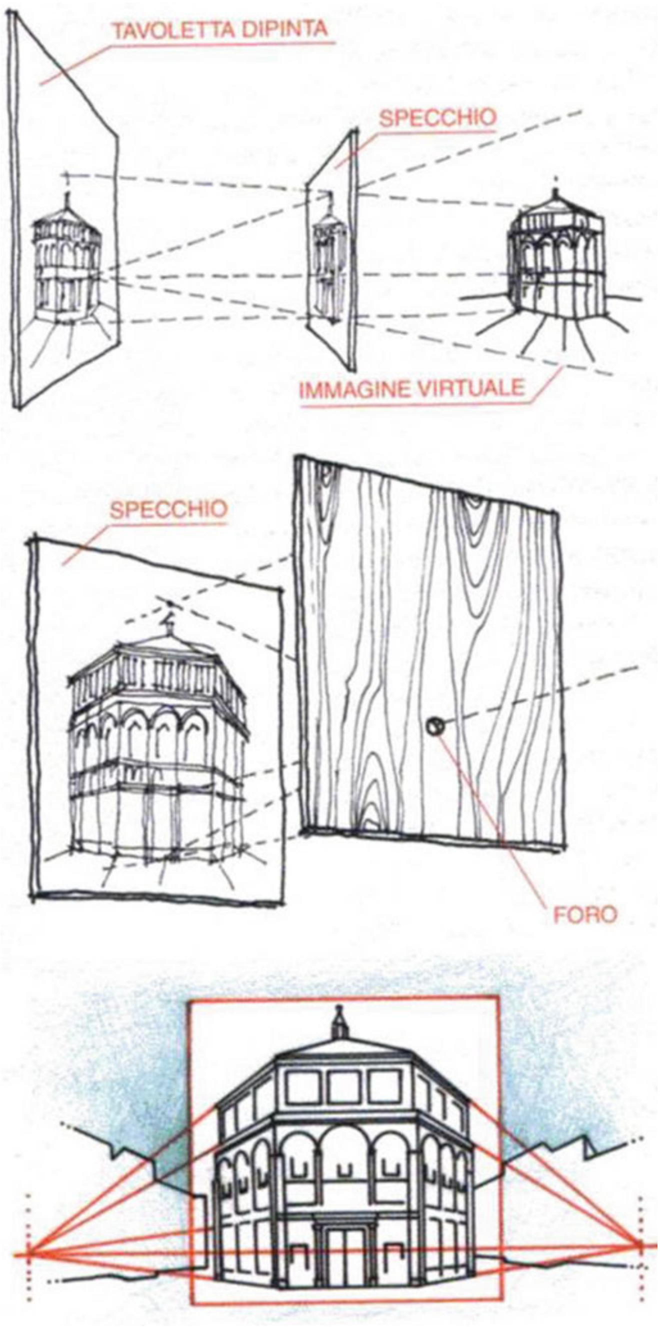


Fig. 6 Perspective view of the Baptistery of Florence (Brunelleschi) (from istitutomaserati.it)

in the Middle age, numbers, weights and measurements became much more important, thanks to contributions of Indian, Persian and Arab scientists and people.

4 The Modern Age

In the middle of XVI century, a group of cartographers and cosmographers was formed in the Netherlands, including Mercator, who reformed the Cartography. As a consequence, a map results from a plane design of Earth's surface, taking into account the Cartesian reference system, as well as Euclidean geometry and Galilean physics. The mathematician and cosmographer Mercator, that studied at the Catholic University of Leuven (the same at which Erasmus had been a student), is also known for a treatise on triangulation.

According to Descartes: the extension in length, breadth and depth, which constitutes the space occupied by a body, is exactly the same as that which constitutes the body; consequently there can't exist a space separate from body; space, time and motion are just relations among bodies and not separately existing entities or attributes, which are in any way independent of material bodies; also motion only exists as a relative difference among bodies.

According to Spinoza: number is used to determine the discrete amount and measurements determine continuous quantity; man, as mind and body, is a simple determination of two dimensions of the essence of God: thought and extension. Time, in contrast, explains duration, being relative and not an absolute entity; since it is not a divine property.

Indeed if a man observes a phenomenon knowing all its causes and all its premises, he will arrive at a statement devoid of any reference to time, and always true. However a man can't know all causes and consequences of things, and that's why he sees things arise and perish only. During the globalization of the modern era the early development was accomplished by practicability of seas, largely enhanced by availability of better maps. Also Columbus stated, that all points on Earth surface are equivalent as they may be described by merely two coordinates.

Willem Blaeu, a pupil of the astronomer Tycho Brahe, returned to the Netherlands, drew high-quality maps of various States, also forming important Atlases, and became cartographer for the Dutch East India company. Matteo Ricci, with the Chinese mathematician Xu Guangqi, translated the first books of Euclid's Elements in Chinese; he also drew a world atlas for Chinese, personally taking care of the translation of European names in the local language, and introduced in Europe many aspects of Chinese civilization.

In the same period, the Modern Physics was born. Newton assumed, that space is absolute in nature, some sort of void container of objects and facts, based on Euclidean geometry. Quite the opposite was Leibnitz's view, where space derives from relationships between objects, as in Gestalt theory and Psychoanalysis.

The philosophical insights of Cusa, Copernicus, Giordano Bruno, etc. gradually changed the conception of the Cosmos and the idea of a well-ordered world, finite and finalized. Gassend presented the atomistic conception with energy, saying that space and time were pre-conditions for the existence of the substance, not its attributes, and with his statements, he risked charges of heresy. His geometrical and mechanistic conception, which supports the origin of modern physics is the product of Plato's mathematics, evolved into a strange alliance between Plato and Democritus.

Newton founded his mechanics on the idea, that space was distinct from bodies and time would pass uniformly. His universe is an infinite space, in which the bodies move in a straight line unless they are deviated by another body exerting a force. Leibnitz, the great rival of Newton, believed that space is the order, which makes the bodies to be placed and, since they exist together, they have a relative position to each other, and the time also is a similar order, in relation to their next position.

The laws of mechanics are the same for all inertial reference systems, whatever is the velocity, is the well-known discovery of Galileo. Newton worried it, because of his belief in an absolute God. However Newton was criticized for his irrational conception, particularly by Berkeley, who believed, that all material objects, space and time were illusions

The relativity of space was implied in Bruno, who stated, that there are infinite heavenly bodies and endless motions of the universe, all of which can be used to define the time. Galileo saved only relativity of motion, Leibnitz instead followed the idea of Bruno about general relativity of motion, time and space. The phenomenological conception of Leibnitz is a necessary step to understand the next revolution done by Kant.

Locke analysed human intellect, to identify the possibilities and limits. Space and time aren't absolute realities, because space is born from simple ideas, that come from the sight and touch, and time is born by the interior experience of a continuous flow of ideas, which come one after the other (Abbagnano 1982b, Vol. 2). Hume didn't accept any external reality, but only impressions and ideas, of which people have immediate consciousness: people don't perceive a pure and absolute space, but only coloured dots, arranged in a certain order. The idea of space rises from aggregating them in a general name and the same is applied to the time. The geometry is an empirical science, because only arithmetic and algebra are rationally demonstrable. The modern philosopher Russell stated, that Hume's philosophy overcomes also Kantian critical synthesis (Figs. 7 and 8).

Fig. 7 Map of Africa by Mercator (1595) (from Wikipedia)

Fig. 8 Map of the World by Blaeu (1635) (from Wikipedia)

5 The Enlightenment

The Enlightenment and Kant are strictly linked. Indeed according to Kant's philosophical legitimation of Euclidean geometry and Newtonian physics, space and time are inner conditions of mankind, which allow the perceptions and will later be ordered by logical categories, refusing religious assumptions, as generally not done before.

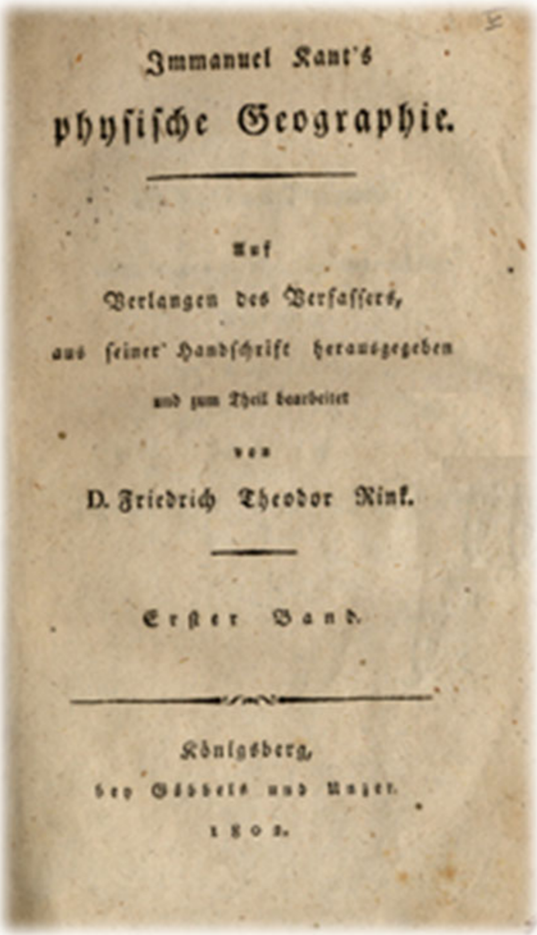
Kant believed, that space and time aren't objective realities, but subjective constraints, which allow sensory-cognitive capacity of the human mind to represent objects, e.g. a priori forms of sensitive intuition. Appearances are phenomena, things in themselves noumena, while space and time, a priori forms of intuition, are transcendental and universal, i.e., they belong to human beings, endowed with reason, thorough logical categories.

The efforts to demonstrate the fifth postulate of Euclid, by Saccheri and Legendre, resulted in the emergence of new non-Euclidean geometries. Thus hyperbolic geometry was due to Gauss, Bolyai and Lobačevskij, and later, Riemann founded spherical and elliptical geometry. Riemann questioned also the uniqueness of Euclidean geometry, which was before considered the ideal abstraction of actual physical space.

At that time, the principal question was if the Earth was a spheroid flattened at the poles or at the equator. Newton preferred the second hypothesis, on the basis of physical considerations, Descartes and Cassini, according Descartes, the first one, on the basis of philosophical considerations.

Kant (Kant 1999) taught at Koenigsberg University physical geography and wrote in lecture notes for his students, that two journeys were organized to measure the degree of meridians: La Condamine, Godin, Bouguer left for Quito, a town then belonging to Peru in South America, and in the following year, Maupertuis, Clairaut, Camus and Monnier went to the Finnish town of in Tornea, to measure the meridian, which crosses the Arctic Circle. After that, the Peruvian expedition, returned in France, confirmed the hypothesis of Newton. Nevertheless the prestige of Cassini wasn't obscured; indeed their methods were used throughout the world, nor were affected by their beliefs. Cassinis and his entire family created a crystalline symbolism, typical of the views of the Enlightenment, the esprit de géometrie, without ornaments or frills, which became the rule for all the maps, since then (Figs. 9 and 10).

Fig. 9 A map of Paris by the Cassini family, (1750-1818) (from Wikipedia)


Immanuel Kant's
physische Geographie.

Auf
Verlangen des Verfassers,
aus seiner Handschrift herausgegeben
und zum Theil bearbeitet
von
D. Friedrich Theodor Rink.

Erster Band.

Königsberg,
bey Göbbels und Unzer.
1802.

Fig. 10 Kant's lessons on Physical geography (from www.spaziofilosofico.it)

6 The Crisis of Science

Initially the crisis of science (Husserl 2008) opened the discussion questioning even Kant's philosophical perspective, whether sensations were organized according to the a priori space and time. Enriques and the Gestalt theory examined the relationship among physical, psycho-physiological and geometrical spaces. Projective Geometry and Topology are closely related to Photogrammetry and Image Analysis, where the last one gives new interest to Projective Geometry.

Poincaré said there isn't an absolute space and only relative motions are conceived, there isn't even an absolute time and the equality of two durations of time depends on conventions, the intuition of the simultaneity of events occurring in different places doesn't exist. Geometric space is different from the one perceived by proper senses: continuous, infinite, three-dimensional, homogeneous and isotropic.

Relativity's Theory and Quantum Mechanics were the most important developments of the Physics, in the last century. Restricted and General Relativity Theories are related to Space Geodesy, while Quantum Theory relates to Nuclear medicine and Spectral Analysis of materials (whose needs may involve Survey and Mapping disciplines).

Heisenberg (Heisenberg 1994), summarizing the achievements of Quantum Mechanics, said that at the heart of the question is always the antinomy of Kant, so it's very difficult to imagine, that the matter can be divided indefinitely, on the other hand, it's equally hard to imagine, that this division has at one point an abrupt end. He put some questions: what is the proton? … the electron can be divided or not? … the quantum of light is simple or compound? … and stated, that all these questions are ill-formed, because the terms split or consist of have largely lost their meaning. Problems, language and thoughts, i.e., natural philosophy, should be adapted to this new situation created by the experiments, but this is unfortunately very difficult. The word "split" loses its meaning. If one wants to compare the knowledge of the current particle physics to some previous philosophy, this may just be the Platonic philosophy. In fact, the particles of modern physics, as taught by the quantum theory, are representations of symmetry groups and thus are comparable to symmetric bodies of the Platonic doctrine. Aristotle wondered: if between a substance and another there is nothing, how can coexist space and void? … The philosophical question was overwhelmed by the success of Newtonian physics, which allows great practical results, but remained in the background.

Einstein, with his Theory of Relativity, placed geometry within physics, where space and time aren't separate, but they are a complex structure, able to account for the limit of light speed and the effects of gravity, with the curvature of space-time. He was initially influenced by Mach, reflecting on the problem of being and non-being and answering, that the gravitational field was thus not within the space, but it was the space itself. As a consequence, space isn't a rigid container, but bends, twists, is flexible, so that the Sun bends space around and Earth then moves straight into a space, which tilts. Moreover not only the space sags, but also the time; indeed time flows more quickly rather at the top than at the bottom, near the Earth. The concepts of space and time were no more absolute, but relative, i.e., dependent on the reference system, in which is the observer. Space and time vary in function of the speed, with which the observer moves with respect to another at rest, so that the higher the speed, where the light speed in the void is the limit, the more extreme effects will be measured (the time dilatation and the contraction of the lengths). Gravity is due to geometric deformation of space-time, due to the presence of masses.

If philosophy, according to Kant, has always to be referred to a scientific fact, historically variable, what about the a priori system, shaped on the Euclidean-Newtonian geometric-scientific paradigm, that seems to be surpassed by Relativity Theory as and Quantum Mechanics. However, Cassirer (Cassirer 2015) incorporated Riemann's geometry and the Relativity Theory into neo-Kantian critical philosophy, and showed how the Kantian philosophy enters in the development of modern science from Galileo up to Einstein and Gödel. In contrast, Reichenbach believed, that the Kantian method wasn't else than an analysis of Newtonian mechanics and the original Kantian conception of the a priori must be adjusted by the historic awareness of relativity and its new formal apparatus. The ontology should make place to the analytic intellect, studying the conditions in advance, also historical and transcendental, which govern the formation of the object of investigation in the different sciences. Terms like energy, air, atom, space and time, don't designate realities, but they are only symbols for the description of the context of possible relationships.

It's known, that the two theories are contradictory, so a new challenge of contemporary science is to find a theory, which includes the gravity into Quantum Mechanics. Anyway describing the physical laws without reference to geometry is similar to describing thoughts without words and the foundations of geometry had deep physical meaning in this problem. Both Einstein and Gödel believed, that the world was independent of the minds, yet rationally organized and open to human understanding. Both believed, that the progress of knowledge was due to a contamination of science and philosophy and, why not, symbolic moments.

Logics increased in complexity, growing from De Morgan, Boole, Frege, Peano and Russell, in the 19th century, to Tarsky, Quine, Gödel, Reichenbach, Schlick, Carnap and Popper, in the 20th century, recognizing its limits and the conflictual balance between experimentation and demonstration. As a consequence, neo-positivism philosophy is no more knowledge and becomes a mere fact of linguistic clarification. This results in a change of ontological status for Survey and Mapping disciplines, with conjectures and confutations replacing experience and, for Data Processing, Bayesian probabilities rather than frequentist inferences.

In the Knowledge of the External World, Russell had even positioned logics as the locus of scientific method in philosophy. Thus the philosopher can't do more than analyse the only meaningful discourse and, in particular, the scientific one (Abbagnano 1982c, Vol. 3). The propositions of metaphysics aren't simply false, but meaningless, because its aim is to study entities about which nothing can be said, according to the first Wittgenstein, in the Tractatus Logicus-philosophicus. Then for the second Wittgenstein, in the Philosophical Research, philosophy is something whose place is above or below the natural sciences and the human histories, not beside them.

The Vienna Circle was organized by Schlick, who was murdered on the steps of the university by a Nazi. Logical positivism (or neo-positivism, or logical empiricism) spread to the rest of Europe and in English-speaking countries. Many of the logical empiricists could see in some version of verifiability the tool, by which to carry on their anti-metaphysical program. Only empirical propositions are meaningful: they are verified by repeated experiments (as scientific theories, according Carnap and Reichenbach), or by analytic statements, which are true by definition (as mathematical propositions) and become false only by contra-examples (Popper 1970).

The goal was the Kantian theory of a priori synthetic judgments. To the logical empiricist, all statements can be divided into two classes: analytic a priori and synthetic a posteriori, where there aren't synthetic a priori statements. An important aspect of Carnap's and Quine's analysis were their attempt to give precise definition to the distinction between analytic and synthetic statements, by the Logical Syntax of Language.

A path, starting from Herbart, passing through Mach, Helmholtz and Boltzmann and leading to the mathematics of Hilbert and the philosophy of Husserl, accompanied the grow of science and technology after Kant until the modern time. Therefore the crisis of science flew along different paths.

Mach shook the faith in the mechanics, also considering, that scientific theories are only easier ways to describe large amounts of data coming from the existent. The physiological space is for Mach perspective, where all spatial sensations have the function to drive in properly movements, in order to take due care for human beings. The geometric space instead is accurate and free from any finality, where the distinction between the two spaces is based on their function.

In opposition to Mach, Boltzmann claimed, that every physical-mathematical formulation idealizes an event and must necessarily be beyond the experience, but right through the succession of hypotheses science tends to give a representation of the world more and more appropriate. Therefore science doesn't necessarily develop in a gradual way, but may progress through conflict, crisis and reconstruction, in a dialectical way. The universe is a system globally in equilibrium, where the equations of mechanics don't distinguish between what is above and below, and also the distinction between past, present and future is meaningless, because the arrow of time flows only for the people.

In this context, at the end of a long path concerning algebra and mathematical analysis, principally due to Euler and Lagrange in the 18th century, and in parallel, Kronecker, Dedekind and Cantor (for theory of numbers), Cauchy and Weierstrass (for the functional analysis), Jordan and Klein (for the topology) in the 19th century, Hilbert founded the axiomatic mathematics, incorporating geometry into algebra and mathematical analysis, and fixing common principles for arithmetic and logics. For these reasons, Mathematical analysis has a direct impact on theoretical Geodesy (and sometimes the last one promoted the grow of Mathematical analysis), while Topology has an impact on Cartography and GIS.

At the same time, Husserl founded Phenomenology, observing that the act of reflection is a process in time, so that human consciousness has an immediate experience of space and time. Empty space hasn't an independent meaning, because it's based on the concept of absence.

In the last two centuries, a similar path, concerning Linguistic analysis, was drawn by the contributions, among many others, of comparative grammar by von Humboldt, structural grammar by De Saussure and transformational-generative grammar by Chomsky, also reaching principles, sources and applications of surveying and mapping disciplines. The very immaterial nature of current Survey and Mapping disciplines may require a grammatical, syntactical and semantic analysis of their language.

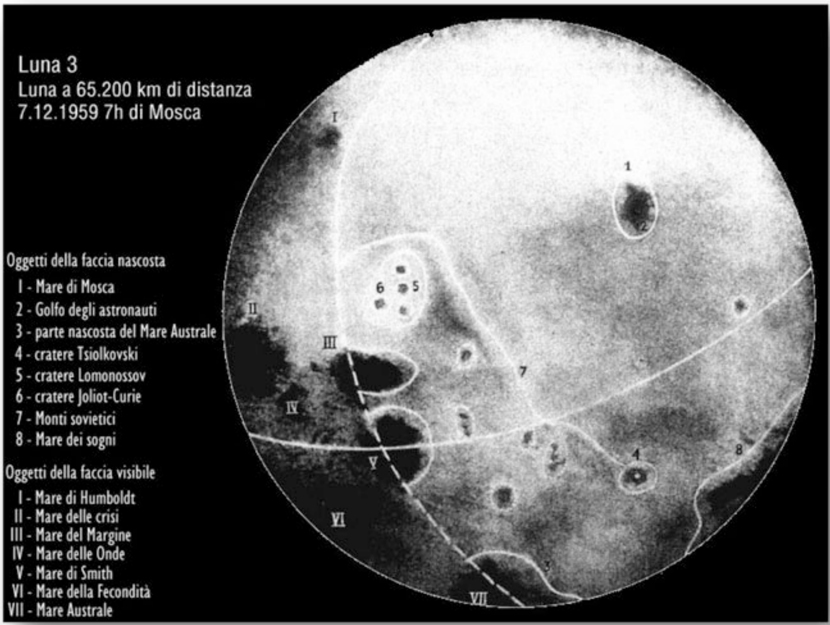


Fig. 11 The dark side of the Moon (from planet.racine.ra.it)

7 Conclusion

After Wittgenstein, philosophy appeared to focus mainly to linguistic analysis; however developments in science and technology reopened some concepts, like space and time versus a new philosophical thought (Hawking 2006), again both had to do with Geodesy and Geomatics. Indeed sometimes, it happens, that different disciplines find their close interaction, when searching for high accuracy measurement. This is the case of the relationship between the geodetic measurements of the heights and the metrology of time and frequency, leading towards a realistic scenario of relativistic geodesy. Therefore the geographical universe isn't just the information supplied by maps, the spatial isn't just the visible, the temporal isn't an independent domain and not all users see the world through the same eyes. Geography is no more than History in space, as well as History is Geography in time.

Geomatics, e.g. space geodesy, image analysis and GIS, deals with the concepts of space and time: for example, space-time integration, mapping starting from different cultural viewpoints about space and time, different scenario investigation, etc. Ideas remain ideas and have no claim to absolute truth, so that truth can only be sought step by step, but convergence isn't granted (Fig. 11).

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