VAN KUNNEN NAAR KENNEN

BAND 2

KOYRÉ vs OLSCHKI / ZILSEL

Koyré vs Olschki-Zilsel

Inhoudsopgave band twee
Content Part Two

- Edgar Zilsel , De opkomst van de wetenschapsgeest, de methoden van het humanisme
- Lesley B Cormack: Handenarbeid en Hoofdarbeid, voorbij de Zilsel Thesis
- Maarten van den Oever: Hoe een ei te breken, Zilsels aanval op twee paradigma's
- Maarten van den Oever: Tussen ambacht en wetenschap: de case van Filippo (Pippo) Brunelleschi.
- Diederick Raven: Koyré vs Olschki-Zilsel
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Colofon

Serie Titel : Van Kunnen naar kennen/From to can to to know.
Deeltitel : Koyré vs Olschki-Zilsel
Uitgave/Publisher: stichting Dubitatio Liberat, Antwerpen, Utrecht, 2018
Geschreven door/written by: Diederick Raven
Editing: Maarten van den Oever

ISBN 9789492752109
Bestelnummer DL022
Editie 1

Deze uitgave is vooralsnog enkel in het Engels te verkrijgen.
This edition is for now only available in English

Alle uitgaven van de stichting Dubitatio Liberat zijn te vinden op de website van de stichting Dubitatio Liberat
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Koyré versus Olschki-Zilsel

Diederick Raven[1]

0. Abstract

In 1939 Koyré introduced the notion of the Scientific Revolution (SR) as a catch phrase that deals with the 'profonde transformation intellectuelle dont la physique moderne' (Koyré 1939:12, cf. Koyre 1943b:400) that he alleged happened at the time of Galileo. For Koyré these changes are due to 'pure unadulterated thought' because, as expressed it in his 1943 critique of the Olschki-Zilsel position, science 'is made not by engineers or craftsmen, but by men who seldom built or made anything more real than theory' (1943b:401). We now know Galileo did quite a lot of experimentation hence this statement by Koyré is no longer acceptable. In this paper I will assess the Koyré argument against the Olschki-Zilsel position. Central to my argument is that only by applying a comparative framework such as developed in my book *The European Roots of Science* (Raven 2015) it is possible to through light on this vexed issue.

> *''The Creator conceived the Idea of the Universe in his mind (we speak in human fashion, so that being men we may understand), and it is the Idea of that which is prior, indeed, as has just been said, of that which is best, so that the Form of the future creation may itself be the best: it is evident that by those laws which God himself in his goodness prescribes for himself, the only thing of which he could adopt the Idea for establishing the universe is his own essence….. so that it [the universe] might become capable of accepting this Idea, he created quantity.''*

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Johannes Kepler *MC*, p. 93-5; *KGW*, i, 24:1ff. [2]

1. Introduction

Edgar Zilsel (1892-1944) is best know for the thesis named after him which holds that modern science could emerge only when the hybridization of the conceptual resources of the Scholars with the manual skills of the Artisans was made possible at the time of Galileo. Zilsel started research on this theme in 1929, possibly a year earlier, but he wouldn't publish anything of it until he arrived in America in 1939 (for details see Raven 2003). His best-known statement of it in his essay "The Sociological Roots of Science" was only published in 1942 in the journal *The American Journal of Sociology* (Zilsel 1942= Zilsel 2003 Ch 2). From a historiographical point of view the Zilsel thesis is an answer to a problem Olschki first formulated in his *Die literatur der Technik* of 1919. In this book, which is the first volume of his three volumes comprising *Geschichte der Neusprachlichen wissenschaftlichen Literatur* (1919-27), he analysed the emergence in the Renaissance period of a new genre of books written in the vernacular dealing with nature-knowledge. Olschki believed that by studying these texts it was possible to "lay bare the cultural preconditions of the development of science". In his interpretation this new genre

> ''Arose when the secularization of the forms and conceptions of life forced men to draw the sciences, which had removed themselves far from the world, into the sphere of practical and mental activity . . . This is why scientific literature in the vernacular starts with applied and empirical sciences, so as to find, once having arrived beyond the limits of practical necessities, the road towards purely scientific abstractions in an independent way. The end point of this development, which this history of the rise and formation of early scientific prose is devoted, is to be found in the work of Galileo and of Descartes, whose creations and discoveries are not the emanation of ancient and medieval methods of inquiry but rather the further development and triumph of an idea (1919:6)''.

What Olschki tries to come to grips with is the relation of modern science to the artisanal tradition of the preceding and contemporary "artisans". To put it in dramatic

[2] In referring to Kepler's work the following acronyms will be used *MC* for *Mysterium cosmographicum* = Kepler (1981) [1596]; *HM* for *Harmonices mundi* = Kepler (1969) [1619] and *KGW* for (Kepler's) *Gesammelte Werke* = Kepler (1937) ——.

terms: what has Galileo's spectacular description of the arsenal of Venice – right at the start of the First Day of the *Discorsi* – got to do with the theoretical weightiness latter on? [3] This is what Lynn White (1978:123) has christened the Olschki problem.

About the same time Zilsel published his *AJS* essay Olschki published two essays dealing with Galileo's life and work (1942, 1943). Why Olschki felt the urge to publish these two essays is in need of clarification but Koyré was clearly challenged by them and felt obliged to make some strong counter statements. The best known of these undoubtedly are "it is thought, pure unadulterated thought, and not experience or sense-perception, . . . that gives the basis for the "new science" of Galileo Galilei" (Koyré 1943a:346 =1968:13) and "Their science, [i.e. Galileo's and Descartes's] is not made by engineers or craftsmen, but by men who seldom built or made anything more real than a theory" (Koyré 1943b:401 = 1968:17). Both these statements need to be seen in conjunction with Koyré taking at face value Galileo's reply to his empirically minded Aristotelian opponent who challenged him if he did "make an experiment?" to which Galileo's replies "No, and I do not need it, as without any experiment I can affirm that it is so, be cause it cannot be otherwise", (Koyré 1943a:346 = 1968:13). Echo's of this response by Galileo can be found in Koyre's indirect dealing with the Olschki problem when he wrote Galileo "did not learn *his* business from the people who toiled in the arsenals and the shipyards of Venice. Quite the contrary: he taught them *theirs*" (1943b:401 = 1968:17; emphasis in the original) a position that is no longer assailable; for details see Renn and Valleriani (2001).

The scandal of current historiography of science is that ever since the day of Olschki, Zilsel and Koyré there hasn't been any noticeable progress on dealing with what happened in the trading zone between artisans and intellectuals and why it happened at all.

By far the best and most comprehensive analysis of the radical change in mechanics of the Seventeenth century to date is Bertoloni Meli's outstanding *Thinking with Objects* (2006). But at no point does he even begin to offer what is crucial to dealing with objects via instruments: a systematic treatment of the relation between artisanal and theoretical knowledge. The problem shows up in Pamela Long's *Openness, Secrecy, Authorship* (2001) as well. The issue in question is that books written by artisans and humanists (Alberti, Machiavelli) on mechanical arts like mining, metallurgy and mathematics, may provide a common ground for princely rulers and social mobile artisan practitioners. But her claim that "such authorship had

[3] Salviati's famous opening words of the *Discorsi* are "The constant activity which you Venetians display in your famous arsenal suggests to the studious mind a large field for investigation, especially that part of the work which involves mechanics; for in this department all types of instruments and machines are constantly being constructed by many artisans, among whom there must be some who, partly by inherited experience and partly by their own observations, have become highly expert and clever in explanation" (Galileo 1954:1).

broad *epistemological* significance" (176) is highly problematic. She claims that "authorship created discursive forms out of skill based practices" in order to "connect the world of empirical practice to the world of learning" (*Ibid*) in that by "formulating their principles in treatises" these artisan authors "created potentially learned disciplines out of arts previously primarily concerned with craft production and construction" (246). No doubt that authorship helped to raise the social status of the artisans and was beneficial to the social position of mathematical practitioners in general. But like Bertoloni Meli the issue Long never addresses is why there was a *need* to "create disciplines of knowledge out of practices formerly primarily based on craft skill" (176). One way the see the depth of the problem at hand is that with artisanal knowledge talk about (rational) principles isn't in any way meaningful simple because skill based practices aren't subject to (rational) principles (cf. Raven 2013).

The aim of this essay is to assess a new this classical argument about the pros and cons of the Artisan-Scholar thesis while taking as my starting point three assumption. The first is that Koyré's take on the topos is flawed. The same holds true for Zilsel's position. The crucial weakness of the Zilsel argument is that it never has been able to through light on the question of why a craft, a fabricative, material product-making activity grounded in manual dexterity, that aims at getting things build, should all of sudden start to worry about (theoretical) utterances being true. Or to formulate the problem in a different way: Zilsel never sees the need to answer the question why truth questions become important when dealing with artisanal knowledge.

My third starting assumption is that Olschki descriptive take on the topos of the joining of brain and hand comes closes to the truth. The important point is that he never accepted the implication of Zilselian argument: erode the barriers and experimental science naturally emerges. Unlike Zilsel Olschki was acutely aware that what the scholars got out of this social intercourse was something "fundamentally different" than what had gone on before in the artisanal tradition. The difference is that the artisanal experience of the workshop becomes a suitable source of knowledge for drawing "the preliminary lines of the *theoretical* foundations of the mechanical arts". It's because of this that both the questions and solutions are "fully independent" from "the direct tradition of the workshops" (Olschki 1927:156-7, emphasis added). It is clear that thinking with objects and instrument did start to take hold at the time of Galileo but nobody seems to be able to explain what is happening in the trading zone in which intellectuals, humanists and artisans interacted and even more important why it is happening at all. What needs to be elucidated is: what is the relation between artisanal knowledge and theoretical knowledge and why the two all of a sudden become relevant to each other. We need to be able to illuminate why artisanal experimentation – which aims at producing new configurations of interlocking artefacts as a sustainable result – is transformed into scientific experimentation – the aim of which is to test an explanatory principle or to

verify a theory. It is my claim that only when viewed from a comparative angle is it possible to suggest answers to these important queries.

2. Simon Stevin vs Galileo Galilee

If we are to progress in any way on the Artisan-Scholar thesis we need to be able to illuminate what Olschki described as what is "fundamentally different". The prime observation is that the practical problems treated in the vernacular artisans' literature and the ones Galileo was struggling are indeed different: practical versus theoretical. Strongly suggesting there is more to the social emergence of modern science than the rise of the social status of the artisan and more than the artisans emulating the intellectual way of communicating, i.e. via texts.

The proto type artisan, who most clearly fits Zilsel's argument, is the Dutchmen Simon Stevin (1548/9-1680). Stevin is one of the best known of a group of people referred to by Zilsel as superior artisans. Galileo is my exemplary figure. His career provides the best guidance on what is central to the Zilsel thesis. What is special about Stevin's life and work is that he started as an artisan, went to university (Leiden) at the relative late age of 35, but acquired international fame through writing books (*De Thiende* 1585), and rose to high social prominence. He became chief engineer to Maurits, Count of Nassau (1567-1625), in 1592 he became director-general of the Dutch authority for public water works ("waterstaet") and later on in life became quartermaster-general of the army of the States-General (cf. Dijksterhuis 1943).

Galileo on the other hand started his career as a low paid mathematics professor who had to make ends meet by turning his house into a lodging place for his students. Later in life, in 1610, did he raise to fame as the natural philosopher attached to the court of Grand Duke Cosimo II de Medici (1590-1621). For Galileo this transition from mathematical practitioner to natural philosopher always was significant; it legitimated the explanations he gave of natural phenomenon (cf. Biagioloi 1993). Mathematicians did the measuring and in case of astronomy provide "a calculus which fits the observations" (Osiander), philosophers provided the reasons, i.e. causes, of the phenomenon. Philosophers not only had a higher social and intellectual status than the mathematicians reflecting a cultural preference that the providing explanations was the socially higher esteemed activity (cf. Biagioloi 1989, Westman 1980).

The difference between Stevin and Galileo is what interests me here. Stevin, like Leonardo before him, always remained the artisans, engineer in today's parlance. Galileo frequented the artisans' workshops, but always aspired to become a

philosopher, and became a secular theologian. Galileo's crime was a social one: he ventured into the domain of the intellectuals, claiming that his way of investigating God's acts provided a better understanding than theirs. In Galileo's life and work, more than in Stevin's, you see what Olschki's "radically different" actually is: the seizure of questions that belong to the domain of the theologians and answers them in part in terms of what artisanal knowledge would tell you is the case.

The opening scene of the *Discorsi* is significant here. Why is it that the dimensions of stocks, scaffolding and bracing used to launch a big vessel are different to those used for smaller ones? The answer "one cannot argue from the small to the large, because the many devices which succeed on a small scale do not work on a large scale" (Galileo 1954:2) isn't exactly satisfactory. This is a typical artisanal answer to a typical artisanal observation. A home-based version of it is: if you need a teaspoon of salt to cook 1K of potatoes you don't need ten teaspoons to cook 10K of potatoes. (Try it if you don't belief me.) Artisans maybe satisfied if they are able to work out how to change the dimensions of scaffolding in relation to the size of the vessel; the natural philosophers aren't satisfied with vague rules of thumbs; they want to know the reasons, the causal generative mechanism, behind it. Galileo's argument is that with increasing dimensions geometrically similar beams are not equally strong but instead become successively weaker – eventually the bigger beams break under the actions of their own weight.

The significance of the opening scene is this: an artisanal way of going about building a ship raises a question that requires a theoretical explanation. For my, that exactly is the kernel of the Zilsel thesis: artisanal knowledge becomes in need of theoretical elucidation and justification. Artisanal knowledge is appropriated by natural philosophers and along the way it is transformed into conceptual knowledge.

What happens in this process of appropriation – usurpation if you think that knowledge domains that aren't experimentally validated have merit of their own – is: the artisanal tradition of learning through acquisition of skills, and the university tradition of learning conceptually mediated knowledge, by grasping the underlying theoretical principles, become intertwined. The net result of this amalgamation of a bookish and intellectualist tradition that is interested in universals and truth with a manual, mundane, and practical tradition that is interested in particulars is:

a: the empirical and quantitative methods of the artisans gets transformed into the verification practices of controlled-variable experimentation;
b: the empirical found rules of thumb are transformed into the theoretical idea of laws of science;
c: experimental practices are placed in a hierarchical subordinate position to that of the theoretical mode of understanding;

Without a doubt the increase in social status of the artisans, from the twelfth century on, is a highly significant and characteristic phenomenon of Latin Europe – it is beyond the realm of possibilities in *ru*-China.[4] But the crucial step is that the maker's knowledge tradition is accepted as yielding legitimate and valid knowledge. Francis Bacon as the propagandist of this idea is the all-important figure here. The focus of attention in the Zilsel thesis needs to be shifted to the reaching out the intellectuals to the artisans: reaching down instead of rising up. Not the artisans becoming natural philosophers – which hardly ever happened – but the other way around the academically trained natural philosophers becoming artisans – which also hardly ever happened exceptions of Boyle, Huygens, Newton not withstanding – but they always had at their disposal a socially invisible Hook like figure (or an even more invisible instrument maker) beavering away in a laboratory, somewhere hidden at the back of a grand home, who had the required artisanal skills, did all the dirty work, and produced the relevant experimental data. *Experiment based natural philosophy, was created when the artisanal conception of knowledge was appropriated by and incorporated into the theoretical conception of knowledge of the scholars.*

It is in this light that I propose the following cultural re-formulation of the Zilsel thesis:

> The (monistic) artisanal conception of knowledge fused with the (dualistic) intellectualist conception of knowledge.

Because the two learning strategies do not cohere they all the time tend to drift apart. Confluence doesn't apply on a personal or group level but only on an institutional level. All that is required is that institutionally the empirical content of theoretical concepts is somewhere validated and experimental data theoretically are somewhere illuminated. Without a doubt culturally the bias always was towards esteeming theoretical curiosity and understanding: *la più degna è la scienzia* (since theory is the most worthy) are the words of *Il libro dell'arte* (Cennini, 1932, I, 17). Galileo is valued more than Brunelleschi, Newton more than Harrison, Einstein more than Edison.

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[4] "Of course, there did exist traditions of technical natural knowledge in traditional China. But most often they consisted simply of technical knowledge used for practical purposes, such as calendars, healing, divination, manufacturing and warfare; they were not pursued with a theoretical or "intellectual" interest. As such, they were rather isolated from the mainstream of the Chinese intellectual world, their practitioners were distinctly lower in social status than the members of the group called "literati" (*shih*), who were the social, political and intellectual leaders of traditional Chinese society. (. . .) It is certain that the position of natural knowledge in traditional Chinese learning was marginal, much more so than in the medieval West. This is clear from a comparison of the syllabuses of the medieval European universities with the tables of contents of the Neo-Confucian anthologies which were the standard textbooks for the education of the literati", Kim (1982:89).

3. Deus omnium opifice

From a historical comparative perspective the significance of Copernicus is not his rejection of the Ptolemic theory and/or his alleged genius in terms of replacing it with a Helio-oriented theory – Helio-oriented because Copernicus uses a "mean sun" which is merely a geometrical point located outside the real sun but close to it; it was Kepler in his first important work *Mysterium Cosmographicum* (1596) who replaced this "mean sun" with the real sun, i.e. a body capable of physically influencing the other planets in the solar system. This traditional view misses a very crucial point: the Ptolemic *theory* never was. It was a set of complex mathematical rules arranged in such a way that each planet had to be dealt with separately and individually. There was no single mathematical connection between these rules. What is radical with Copernicus is that we are for the first time presented with a single *mathematical theory*.

This point is easily confirmed if we look at Copernicus's own words. In his dedication to Pope Paul III, i.e. his own preface, Copernicus (1992:4) mentions as his second motivation for considering his hypotheses that the astronomers

> ''in determining the motions not only of these bodies but also of the other five planets, they do not use the same principles, assumptions, and explanations of the apparent revolutions and motions. For while some employ only homocentrics, others utilize eccentrics and epicycles, and yet they do not quite reach their goal. For although those who put their faith in homocentrics showed that some nonuniform motions could be compounded in this way, nevertheless by this means they were unable to obtain any incontrovertible result in absolute agreement with the phenomena. On the other hand, those who devised the eccentrics seem thereby in large measure to have solved the problem of the apparent motions with appropriate calculations. But meanwhile they introduced a good many ideas which apparently contradict the first principles of uniform motion. Nor could they elicit or deduce from the eccentrics the principal consideration, that is, the structure of the universe and the true symmetry of its parts. On the contrary, their experience was just like some one taking from various places hands, feet, a head, and other pieces, very well depicted, it may be, but not for the representation of a single person; since these fragments would not belong to one another at all, a monster rather than a man would be put together from them.''

In a word Copernicus' principal consideration for "revolutionizing" astronomy is to be found in replacing the monster created by the astronomers by *unifying* the parts

under the heading of symmetry, a notion that initially not needs to be understood from a mathematical perspective but in its etymological sense of "agreement in dimensions, due proportion, arrangement".[5] As Rheticus points out in his exposition of the Copernican argument "there are only six moving spheres that revolve about the sun, the centre of the universe. Their *common measure* is the great circle that carries the earth" (Rosen 1959:146-7, emphasis added).

In the Aristotelian ideal of knowledge "knowledge" means lying bare the causes of the phenomena. Despite all the critique this ideal was subjected to in the Middle Ages we see that the likes of Copernicus, Clavius, Kepler and Galileo all slowly edging towards arguing for the reality of astronomical hypotheses and hence all of them reluctantly accept a physicalisation of astronomical theories. In Kepler this is clear form the title of his 1609 work *Astronomia Nova, Aitiologetos, sue physica coelstis* which in translation renders *New Astronomy based upon Causes or Celestial Physics*.

But the emphasis on causality, and its realistic interpretation, implies, once one accepts the Aristotelian idea of a physical science, the specification of an efficient cause, specifying a concrete "physical cause" that actually is operative in the natural world. This leaves open at least two questions: first, the knowability of the universe and second, what to take as "physical" cause.

As for the first question Copernicus's *ration machinae mundi qui propter nos optimo et regularissimo omnium opifice conditus esset* contains this all important phrase *propter nos*: the world is knowable because God made the world *for us*. Normally these two words get all the attention, and rightly so, less attention is given to that all the times Copernicus expresses the idea of God in *De revolutionibus* it always is in terms of *opifix* – artisan or manufacturer. Apart from the just quoted *optimo et regularissimo omnium opifice* (the best and most systematic Artisan) we have *opificem omnium* (maker of everything), *a divina providential opificis universorum* (the divine providence of the creator of all things), *divina haec Optimi opificis fabrica* (the divine handiwork of the most Excellent artisan).[6] If we combine

[5] The Greek "symmetros" is made up of syn- "together" + metron "meter" and means "having a common measure, even, proportionate" so we get that symmetry means "agreement in dimensions, due proportion, arrangement". Although one would think that the Latin "symmetria" derives from Greek "symmetros", as Hallyn (1993:94) makes clear Alberti c.s. were struggling to find the right equivalent for it in Latin. I am deeply indebted to Hallyn's chapter three for my understanding of the argument from symmetry in Copernicus.

[6] The last reference is made at the end of the summary of Cap 10, in book i. The complete sentence is *Tanta nimirum est divina haec Optimi opificis fabrica,* (So vast, without question, is the divine handiwork of the most Excellent artisan). According to the emendations required by the Decree XIV of the Holy Congregation of the Index, 5 March 1616, which placed *De revolutionibus* on the list of prohibited book *donec corrigatur* "until corrected" this sentence had be deleted: *Dele illa verba postrema*, strike out these last words. The closing sentence is the culmination of Copernicus argument in which he remarks that the universe is so large that the stars do not exhibit any noticeable parallactic

this with the Platonic motto ἀγεωμέτρητος οὐδείς είσίτω (Let no-one ignorant of geometry enter here), which is on the title page, the inference has to be that Copernicus' *Deus* is an artificer, an architect, a mathematical artisan who created the world with mathematical principles in mind. In the makers conception of knowledge making implies knowing. With Copernicus we have: made along mathematical lines implies knowing in mathematical terms. Mathematics is the key to understanding the world created for us.

Because Copernicus isn't more forthcoming on this point, if he is elaborating at all he always exercises extreme caution, we need to look elsewhere for elucidation.[7] Despite not having published something that resembles a philosophical essay or monograph Kepler is very articulate on the Christian assumptions of his philosophy of science.[8] Geometry for him is coeternal and coessential to the Creator: "For Geometry, . . . , coeternal with God and shining in the divine Mind, gave God the pattern. . . by which he laid out the world so that it might be best and most beautiful and finally most like the Creator" (*HM*, III, i; *KGW*, vi, 104-5:37-3). In *Mysterium Cosmographium* (1596) he had already stated that

> ''just like a human architect, God has approached the foundation of the world according to order and rule and so measured out everything that one might suppose that architecture did not take Nature as model but rather that God had looked upon the manner of building of the coming (i.e. yet to be created) human'' (*MC*, 53-5, *KGW*, i, 6:7-10; *KGW*, viii, 17:10-14).

Like with Copernicus Kepler's *Deus Artifex* was a geometer, mathematician in today's parlance, who created the world in concord with the norms of the quantities provided

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change. Apparently the Holy Congregation felt Copernicus in this closing sentence suggested in a too definitive way that the Divine Creator had indeed layout the cosmos in a heliocentric fashion.

[7] In what Copernicus says on these matters he is very careful not to provoke the theologians who hold that divine revelation is the only source of truth. Osiander is one of these theologians, hence his *Praefatio ad lectorum.* Example's of Copernicus' cautious wording are: The philosopher "endeavours to seek the truth in all things, to the extent permitted to human reason by God", and "by the grace of God, without whom we can accomplish nothing, I shall attempt a broader inquiry into these matters", Copernicus (1992: 3, 8). The scepticism Osiander express concerning Copernicus theory should not be interpreted in terms of his position being an instrumentalist one but merely expressing doubt about the possibility of getting at real causal knowledge in astronomy given the at time prevailing ideas of explanation. At issue is the following: can you in the case of astronomy turn a *demonstratio quia*, i.e. a "reasoning from the effects" into a *demonstratio quid,* i.e. a "reasoning from the causes".

[8] The one MS that could possibly qualify as such, his *Apologia pro Tychone contra Ursum*, wasn't published during his lifetime – that happened only in 1858 with the Frisch edition of Kepler's *Opera omnia* – and only indirectly deals with the reasons pro and con the Copernican theory; the brief Kepler was given for writing the *Apologia* deals with a priority dispute; he was to defend Tycho against the claim made by Ursus that the idea of the Tychonian hypothesis – a compromise version mixture of the system of Ptolemy and Copernicus – originated with Ursus. Tycho of course claimed it was the other way round.

by geometry. People being created in the image of God (*Imago Dei*) have a mind that is able to understand God's creation. Hence peoples mind is able to recognize these geometrical principles and patterns. In a letter to his former mathematics teacher Michael Maestlin, who at the time of writing had become both a friend and mentor, Kepler would argue that *ut oculus ad colores, auris ad sonos, ita mens hominis ad quaevis sed ad quanta intelligenda condita est* (As the eye was created for colour, the ear for tone, so as the intellect of humans was created for the understanding not just any thing whatsoever but of quantities) and continues

> ''it grasps a matter so much the more correctly the closer it approaches pure quantities (*nudae quantitates*) as its source. But the further something diverges from them, that much more do darkness and error appear. It is the nature of our intellect to bring to the study of divine matters, which are built upon the category of quantity; if it is deprived of these concepts, then it can define only by pure negations'' (*KGW*, xiii, nr 64:12-19).

Arguing that Kepler subscribed to the view that the ultimate structure of the cosmos was imprinted on the human mind is, I belief, stretching things a bit. *Ad quanta intelligenda condita*, the mind is created for understanding quantities. The creation being the material embodiment of God's ideas the mind is attuned to grasp these ideas; *hominum mentes, Die simulachra* (mens's spirits, simulacra of God's spirit; *KGW*, ii, 16:9). Kepler, in his *sacro furori* (*HM*, V, i; *KGW*, vi, p. 290:3), believed he was able "to think the thoughts of God over again".[9] In his *Mysterium* he would claim to have discovered God's blueprint for the universe, i.e. the archetypical assumption behind the way the solar was the way is was. Bewildering as it may seem to the modern reader, the nesting of the polyhedra needs to be understood as confirming a realist understanding of the Copernican helio-centred system of the world. Kepler argues to be able to explain why there are only six planets; the answer is there are only five polyhedra. (These polyhedra are examples of what in Kepler's terminology are called archetypical (geometrical) ideas. God created the universe, more in particular the planetary system with these five polyhedra in mind.)

What enabled Kepler to argue for a realist interpretation of Copernicus theory?[10] For starters we have the teleological principle that "man is the goal of the

[9] Caspar (1993:62). As Barker & Goldstein (2001:102) point out Kepler and many of his contemporises assumed that "knowledge of geometry had been inscribed on the human soul when it was created". In a fragmentary work, *De Quantitatibus*, he would argue for the special principles of mathematics, *quae communi lumine* naturae, which are to be understood by "means of the common light of nature". The unity of Kepler's work is to found in his conviction that he had access, through this *lumine naturae*, to the geometrical archetypes God had used in ordering his providence.

[10] Realism understood here in the double sense of classical Aristotelianism of being able to give an efficient cause and in the more modern sense of: if a theory is based on a sound methodology scientific

world and all creation" (*MC*, IV:107, *KGW*, i, 30: 11-12; *KGW*, viii, 52: 11-12) or formulated differently "most causes for the things in the world can be derived from God's love for man" (*MC*, IV:107; *KGW*, i, 30:8-9, *KGW*, viii, 52:8-9). Additionally there is a metaphysical principle: "the mathematical things are the causes of the physical because God from the beginning of time carried within himself in simple and divine abstraction the mathematical things as prototypes of the materially planned quantities" (*MC*, XI:125, n.2; *KGW*, viii, 62:30-33; aesthetic beauty is as matter of course included in the use of the mathematical ideas; the beauty is founded in the clarity, simplicity and elegance of the mathematical ideas used in the design of the world. The Platonic regular solids are a good example of what is meant here.) Finally there is an epistemological principle: "each philosophical speculation must take its point of departure from experiences of the senses". (*MC*, XII:141, n. 7; *KGW*, viii, 72; 16-17.)

Kepler aspired to become a theologian, ended up a brilliant mathematician, a very gifted mathematical astronomer and a creative philosophical astronomer. Yet, as he discovered much to his surprise close scrutiny of the world leads to the contemplation of God, and hence easily yielded an anagogical – knowledge of nature raise us to what is eternal – interpretation of his natural philosophy: *Geometria una et aeterna est, in mente Dei refulgent* ("Geometry is one and eternal, a reflection out of the mind of God", *KGW* iv, 308:9-10) hence *Deus ecce mea opera etiam in astronomia celebrator* ("Even in astronomy my work worships God", *KGW*, xiii, nr. 23, 40:6).

Without a doubt Kepler's outlook and inspiration – the mathematical harmony of the universe is the embodiment of a theological order – is Christian through and through. In his own words "In der Schöpfung greife ich Gott gleichsam mit Händen, die Astronomie hat Verherrlichung des weisesten Schöpfers zum Gegenstand" (In creation I can reach God who speaks with his hands, astronomy has the glorification of the wisest Creator as its subject).[11] Without this Christian inspiration it would not come to fruition. Needham in his *The Grand Titration* is struggling with the problem why on the one hand in China the idea of laws of nature is lacking and why on the

truth is accessible. A modern-day realist would of course object to this formulation, it seems to invoke the epistemological fallacy, but the point is clear enough: our latest theories have a greater verisimilitude.

[11] Kepler, *Betrachtungen über die Weisheit des Schöpfers bei Erschaffung der Welt*, as quote by Günther, (1905:85). Holton, in his insightful (1956:350) summaries Kepler's philosophical outlook in these terms "The investigation of nature becomes an investigation into the thought of God, Whom we can apprehend through the language of mathematics. *Mundus est imago Dei corporea*, just as, on the other hand, *animus est imago Dei incorporea*. In the end, Kepler's unifying principle for the world phenomena is not merely the concept of mechanical forces, but God, expressing Himself in mathematical laws". Caper (1993:374) expresses the same idea as: "God is truth, and the service to truth proceeds from him and leads to him. God is the beginning and end of his scientific research and striving. Therein lies the keynote of Kepler's thought, the basic motive of his purpose, and the life-giving soil of his feeling".

other hand the West is so confident that the secrets of the Cosmos are intelligible to mortal human beings in a rational way. He toys with the idea that the concept of a divine legislator – which is also absent in China – may have been a necessary element and suggests that China could only come up with the idea of laws of nature if it had passed through a Western style "theological" stage. In similar vein he quite bluntly asks:

> ''The Problem is whether the recognition of such statistical recognition and their mathematical expression could have been reached by any other road than that which Western science actually travelled. Was perhaps the state of mind in which an egg-lying cock could be prosecuted at law necessary in a culture, which should later have the property of producing a Kepler ?'' (Needham 1969:330)

In his *Dioptrice* Kepler remarks he offers the "friendly reader, a mathematical book, . . . that assumes . . . a particularly intellectual alertness and *cupiditatem incredibilem cognoscendi rerum causas*" (an unbelievable desire to learn the causes of things, *KGW*, iv, 334:5-8, emphasis added). What Kepler is expecting from his readers is obviously an accurate description of Kepler's mind-set. But my argument is that it s not just a typical feature of Kepler's mind-set, it's a European craze to be fascinated, not to say obsessed with learning to know the causes of things. In the spring of 1536, at the age of twenty-two, Rheticus (1514- 1574) publicly accepted in the professorship of mathematics at the university of Wittenberg in 1536 with a lecture on arithmetic, the subject central to his teaching assignment. When it comes to expressing the inquisitive attitude required of students he writes

> ''But it is characteristic of the honourable mind not to love anything more ardently than truth, and, inspired by this desire, to seek a genuine science of universal nature, of religions, of the movements and effects of the heavens, of the causes of change, not only of animated bodies but also of cities and realms, of the origins of noble duties and of other such things.'' (Rheticus 1999:91).

This quest for "the causes of change" in the natural world is characteristic for the European tradition. Echo's are to be found everywhere. As examples of such echo's one can point to Virgil's *Felix qui potuit rerum cognoscere causes* (Blessed is he who has been able to win knowledge of the causes of things, *Georgics*, II, 490). Dramatic and equally illustrative is Raphael's identification of philosophy with *causarum*

cognitio (knowing the causes), which is the official name of his fresco, located in the Stanza della Segnatura, and generally known as *scuola Atene*.

In case there is doubt about the correctness of Raphael's point of making philosophy equivalent with *causarum cognition* I provide you with Hobbes's definition of philosophy, as put forward in *De Corpore*:

> ''philosophy is such knowledge of effects or appearances, as we acquire by true ratiocination from the knowledge we have first of their causes or generation: and again, of such causes or generations as may be from knowing first their effects.'' (Hobbes 1994:186).[12]

The crucial point in my argument is that only the European civilization developed and prioritized this idea of knowledge is being equivalent about given (physical) causes. I haven't the space to deal with this in any more detail (for that see Raven 2015). But let me briefly deal with the Chinese notion "Zhi", 智, to get a feel for the cultural distance between the Sinitic ideal of what knowledge is and the European one.

Zhi renders as knowledge and sometimes it is rendered as wisdom but the important point is to grasp is that Zhi is about moral wisdom realized in practice, it is about knowing correctly what *to do*, it is about realization. What emerges from any detailed elaboration of what the indigenous Chinese conception of "knowledge" 智, zhi, is about, is that is part and parcel of the idea of self-cultivation as a "ceaseless process of inner illumination and self-transformation". A process that entails a transforming act upon oneself and via objectless awareness (intellectual intuition) is directed at a communion with 天道 (t'ien tao, Way of Heaven). This is a non-discursive enterprise and to achieve a comprehensive breakthrough in the intellectual grasp, of the nature of the world and the things in it, requires an interfusion and identification of the subjectivity of a human and the objectivity of things. Sure enough, various *ru* schools had different ideas and different understandings about various aspects of what is involved in this "ceaseless process of inner

[12] A little later in this text Hobbes (1994:194) writes: Method, therefore, in the study of philosophy, is the shortest way of finding out effects by their known causes of the same, and in what subject those causes are, and in what subject they produce that effect, and in what manner they work the same. And this is science of causes, or as they call it of δίοτι. All other science, which is called ότι is either perception by sense, or the imagination, or memory remaining after such perception.

illumination". The crucial idea here is that the Chinese construe life as "an unending stream reaching in all direction, into infinity".

The contrast with the European ideal type of what knowledge is of course massive. At its core is the Aristotelian statement δι αποδείξεως ειδεναι "we know through demonstration (*Post*. *An*. 71b 17) yielding the notion of a *scientia demonstrativa*: knowledge of something equals understanding its necessitating causes. A different ideal would require a different meta-strategy of learning. Alternatives which of course were available – the artisans way of immersion into a practice or memorisation, the learning strategy that is dominant in the Islam (Qur'ān is of course "the speech" (*kalām*) of Allāh but its literal meaning is "The recitation") as well as the humanist way of model emulation (*historia magistra vitae est*) which happens to be the one *ru*-China opted for – but non of the scholastics ever aspired to make one an alternative to *demonstratio propter quid* (demonstration of the reason why). They all could agree with Grosseteste's remark *diligens inspector in rebus naturalibus potest dare causas omnium effectuum naturalium* (the diligent investigator of natural phenomena can give the causes of all natural effects (Grosseteste 1912, IX:65).

4. The Christian Roots of Science

Hooykaas (1972:75) hits the nail on the head when he writes "the rise of modern science is to a large extent the rise of experimental science". My reformulation of the Zilsel thesis amounts to the same thing. But there is an advantage to my formulation. I am interpreting the Zilsel thesis through the prism of a theory that is devised to handle the differences between civilisations. This comparative dimension carries over into the reformulation of the Zilsel thesis and is responsible for what to some may look like a convoluted formulation. But the advantage of this formulation is that it allows an opening up of the vexed question why it happened only in Europe. The artisanal way of learning is a way of learning available to any civilisation (Raven 2013:23ff). The intellectualist way of learning isn't; it's tied to quite specific European nurtured assumptions such as

- the cosmopolis is a uni-verse;

- the cosmopolis has a definite invariant underlying rational order;
- humankind possess a divine attribute to discern the truth and falsehood with regard to the cosmopolis.

These assumptions have a validity and legitimacy within the indigenous Christian tradition, but not outside it! Toby Huff, my fellow traveller in this respect, has argued this quite clearly for the Islamic case (Huff, 1995, 2000). The Sinitic case has already been touched upon above.

What drove this appropriating process? After all late medieval natural philosophy was "in a very important way . . . *not* about nature".[13] What necessitated the intellectuals to close the books of Aristotle and open the book of nature? The crucial riddle here is as Pamela Smith (2004:239) correctly formulates it "Why did the intellectuals feel there was need to accept the makers-traditions in the first place"? Smith talks about the artisans laying down the foundations for a new epistemology, a new *scientia*, but this formulation is misleading. Not because there is no epistemological foundation to artisanal knowledge – true as this remark might be – but because the *scientia* isn't new but the conception of *naturae* is. [14] It is this new conception of nature that transformed the contemplative discipline of natural philosophy into an active one. Latin Europe inherited from the Greek *φυσιολόγοι* the idea that there is something about "nature" that requires theoretical elucidation, i.e. there is something *erklärungsbedürftiges* about the cosmopolis.[15] Medieval Europe

[13] Murdoch (1982:174, emphasis added). "True, empiricist *epistemology* was dominant in the fourteenth century. But this did not mean that natural philosophy then proceeded by a dramatic increase in attention being paid to experience and observation (let alone anything like experiment) or was suddenly over wrought with concern about testing or matching its results with nature. (. . .) [I]ts procedures were increasingly *secundum imaginationem*" (*Ibidem*, p.174). As a consequence much of this natural philosophy was *praeter cursum naturae* (beyond the course of nature).
Looked at from the point of subject content and given the considerable overlap natural philosophy justly may be regarded as the parent of modern scientific disciplines. But as Wallace (1988: 213-4) remarks, "Yet in another respect the Renaissance study of nature was deficient in its use of observation and experiment, and generally in the role it assigned to mathematics in its reasoning processes".

[14] 'In early modern philosophy s*cientia* is an honorific term. It refers to knowledge or understanding of truths in the light of principles or causes. *Scientia* is systematic knowledge of truths, truths "deducible" from principles. It is not simply knowledge-that, but knowledge-why, and not simply knowledge-why, but knowledge-why that unifies whole classes of truths known. Again, *scientia* is not merely knowledge why truths *happen* to be true. Instead, it is knowledge that the relevant truths cannot *but* be true given the relevant causes or principles. So it is knowledge of truths within a framework that makes their truth look necessitated by the underlying principles. Described like this, *scientia* is an ideal of both pre-modern and early modern philosophy', Sorrell et al (eds.) *Scientia in Early Modern Philosophy*, p. vii, which is in line with the Greek idea of what *ἐπιστήμη* amounts to.

[15] *Φύσις* (nature) is a Hellenistic notion "that in one way or another lies at the foundation of the whole of Greek philosophical thinking", Frank (1955:44). I have no explanation of why this is the case. Nor do I have any idea why the post-Socratic Greek *φυσιολόγοι* opted for construing truth in terms of facticity. My conjecture is that because of it this highly peculiar European tradition was set in motion in which the cosmopolis becomes in need of an explanation. This peculiarity needs to be seen in

nurtured this idea in the sense of a *scientia naturae*. In Latin Europe, there always was this ethos to come up with a unified understanding of nature. An ethos that has no counterpoint in *ru*-ist China. *Ru*-ist thinking is interested in the study of how men can best he helped to live together in harmony and good order, not in explaining nature. The same holds true in Islamic thinking as expressed in the elegant phrase of Rahman (1979:32) "the basic *élan* of the Qur'ān is moral".

What does a diachronic reading of the reformulated Zilsel thesis suggest? Why do the scholastics belief the Greek conception of nature and its associated conception of knowledge is in need of revision? The problem is not that no agreement among the *physiologoi* was ever reached on what to take as the constituents of nature. The problem is that the Greek conception of nature as partaking in the divine and hence as animated and having an agency (teleos) of its own runs counter to indigenous Christian assumptions. The same goes for the Greek idea that the object of knowledge of the human intellect is the essence of the material thing. Can a Christian agree with the assumption that the intelligent comprehension of form is sufficient for the understanding both of what is and what happens in the actual world?

The Greek philosophical ideas about what knowledge is and the indigenous Christian tradition only meet in earnest when the Greek corpus of text became available to Latin Europe in the eleventh century. As the scholastics were to discover the Christening of Aristotle proved to be a much harder job than Christening of Plato – a job already done by the early church fathers.[16] Initially the biblical view was only superimposed on, but could not overcome, the Aristotelian conception. The symbiosis of the Aristotelian philosophy of nature and the Christian understanding of God's infinite liberty and power "rested on an unequal consideration of the attributes of God, on a subordination of the omnipotence and, even more, of the omnipresence of God to the spiritual self-sufficiency and the constant and constitutive dependence of the world on the inner life of the divinity" (Blumenberg: 1987:164). The indigenous Christian revolt was lead by Etienne Tempier, Bishop of Paris, and culminated in the condemnations of 1270 and 1277. Between the Christian God who was able to create at a single stroke the world with the multiplicity of beings it holds and the Greek

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conjunction that in Greek thinking the existence of a thing and the reasons for it existence are distinct. (Something that is enshrined in the very structure of the language in that subject and object have different names and have different casus.) In order to know the definition (τι εστι) of a thing, it must first exist. (For us mortals it is impossible to come to know what a non-existent kind is, simply because it does not exist. "Anyone who knows what "man" or any other thing is must also know that it is; because no one knows what a non-existent thing is" (*Pos An* 92b4-6)). This split between existence and reasons, central to both Plato's and Aristotle's account of knowledge, is what accounts for the identification of knowledge of a thing with grasp of its cause.

[16] Until the big translation movement of the 12th century Plato's oeuvre was only partially known to Latin Europe: parts of *Timaeus* and from 1156 *Meno* and *Phaedo* but the Latin's loved him, for as, William of Conches wrote 'he is in agreement with our faith', *Dragmaticon* I, p. 13.

demiurge for whom effects proceed one by one and according to a necessary order "no conciliation was possible" (Gilson 1955:407).

The radical shift from a *natura naturans* (creative nature) to *natura naturata* (created nature) had to be matched by a shift from a realist reading regarding concepts to a nominalist one. With the Platonic demiurge "productive and theoretical insight converge" (Blumenberg 1985:152). This is compatible with the scholastic understanding of universals as *universale ante rem* (universal having an existence prior to things) and construing the individual as the repetition of a universal. For a Christian the world is non-necessary on account of its origins from nothingness. God's *potentia absoluta* (absolute power) requires a denial of universals and the assertion of the priority of reality over concepts. Put in other words the concept of an absolute will is incompatible with the question of the reasons for its acts. Indigenous Christian reasons are behind the rejection of the Greek idea that the intelligibility of nature is located in nature's own intelligence in favour of the idea that the intelligibility of nature is located in something other than nature: in the *Deus artifex* (God the artificer), the divine creator and ruler of nature. In this process nature is robbed of its necessity and endowed with contingency, necessitating an empirical approach to knowledge. An epistemology based on universals – in which concepts possess a binding force as exemplary entities independent of things and which is the scholastic way of saying that nature is cognitively accessible to man due to reason's experience with itself – is replaced by nominalists one – only individuals exists and concepts are mere words. Man imputing order on nature replaces the idea that the order of nature is adapted to the needs of reason.

Indigenous revolt? But the doctrine of *creatio ex nihilo* is "not demanded by the text of the Bible" (May 1994:24). As Von Rad (1970:48) points out "One most not deprive the declaration in [Genesis] verse 1 of the character of a theological principle. If one considers vs 1-2 or 1-3 [at the beginning when God created heaven and earth, DR] as the syntactical unit, the word about chaos would stand logically and temporally before the word about creation. To be sure, the notion of a created chaos is itself a contradiction". In short in the book Genesis it is clearly all stated that God created order from chaos and secondly that the creation – from pre-existent materials! – is dependent upon God as well as subordinate to him. Still the notion of God as the superior artisan of the universe – *summus namque opifex universitatem* in the words of Honorius of Autun (1080-1154), *Elucidarium*, *PL*, CLXXII, Liber XII, cap ii, 1179 – is distinctly Christian (see picture 1). It is a Christian theological innovation although of a defensive nature, a theological reaction to Gnosticism.

The root metaphor of *liber naturae – scriptus digito Dei*, written by the finger of God (Hugh of St Victor (c. 1096-1141) *Erudit Didascalia*, *PL*, CLXVI, VII, 4, 814, echoing Exod, 31:18 were it is written that when God had finished communing with Moses he gave him two tables of testimony, tables of stone, written with the finger of God) – needs to be understood in conjunction with the metaphor of God as the

superior artisan; the readability of the book of nature is an expression of the idea that the universe is an intelligible entity. Key to the makers-tradition of knowledge is the idea that the only reality with which an inquirer can have any commerce is reality as he constructs it to be. *Verum esse ipsum factum* – the truth is what is made. Nature is readable because God created it (for man, *proter nos*, as Copernicus would have it). The bible, Wisdom (11:21), states that God had ordered all things *mensura et numero et pondere* (measure, number and weight) as well (13:1) that God may be known as *artifex* (artist). Suggestions that God had used mathematics as the language for his public manuscript can be traced back to Robert Grosseteste, Bishop of Lincoln (c. 1175-1253) and Roger Bacon.[17]

God created the universe consequently it is knowable. Artisanal knowledge is created knowledge therefore knowable. At his point Galileo's question of "What has philosophy got to do with measuring anything?" is relevant. Measurements, weights and numbers are the route to the knowable world. Natural philosophers sought causes not quantitative relations. Hence the transformation of these numbers into the triangles, circles and other geometrical figures and symbols of the mathematicians. And this brings us directly to Galileo's social crime: arguing the book of philosophy *è* [un libro] *scritto in lingua matematica* (Galileo 1968, VI: 232).

In 1930 Zilsel wrote that the search for the idea of scientific laws is what sets Europe apart from other civilizations: "For four centuries the search of scientific laws is progressing. This and only this is what Europe is, modernity is, science is" (1930:421). This quote illustrates the huge significance the concept of scientific law had for Zilsel at quite an early point in his thinking. I have never felt that his ideas on the emergence of notion of scientific laws (2003: ch. 6) sits easily with the thesis named after him. One reason is that a key idea of modern science is to be located outside the realm of the artisans: in the Judeo-Christian notion of a divine lawgiver. That is to say that "[t]he very idea of a law of nature, from the moment of its birth, was underpinned by theological considerations" (Harrison: 2008:14).

Exploring the ramifications of this idea is easy if one accepts the congruity of grace and nature – for the likes of Boyle, Galileo, Kepler and Newton, the study of nature is an act of worship; Kepler, *KGW*, XIII, p. 193, sees himself as a "priests of the

[17] "The usefulness of considering lines, angles and figures is very great, since it is impossible to understand natural philosophy without them. They are useful in relation to the universe as a whole and its individual parts. . . . Now, all causes of natural effects must be expressed by means of lines, angles and figures, for otherwise it would be impossible to have knowledge of the reason (propter quid) concerning them" Grossesste in Grant (ed.) (1974:385)). Kepler, *MC,* cap XI, note 2, p. 125, *KGW*, Vol VIII, p. 62, would later express this idea as "the reason why the Mathematicals are the cause of the natural things – a theory which Aristotle carped at in so many places – is that God the Creator had the Mathematicals with him as archetypes from the eternity in their simplest divine state of abstraction, even from quantities themselves, considered in their material aspects.). It is Roger Bacon (1897:97) who at one point writes *quoniam qui ignorat earn non potest scire caeteras scientias nee res hujus mundi*, (he who ignores (mathematics) cannot know the other sciences, nor the affairs of this world".

highest God in regard to the book of nature" – an option that would in effect derail to a large extend Zilsel's sociological argument. Zilsel "explains" the issue of the emergence of the notion of physical law as "caused" by the rise of the absolute state. Seen from a comparative angle this cuts no ice. If ever there was an absolute state Imperial China most be it. *Ru*-thinkers never even came close to develop a notion of scientific laws. Latin Europe developed this notion as an alternative to the teleological notion of causes it had inherited from the Greeks and exemplified in Aristotle. For a secular theologian like Descartes (1904:380) the laws of nature are the rules and ideas God had used in creating the world: *quia deus sic voluit, quia sic disposuit* (because God so willed and so ordered). Its emergence is part and parcel of the reconfiguration of nature necessitated by the Tempier condemnations. Only with Descartes do the secular theologians arrive at a fully developed notion of laws of nature and is the reconfiguration of nature completed (Henry 2004).

At the centre of my comparative dealings with the Koyré – Olschki/Zilsel dispute are two robust claims. One, as already mentioned above, is idea that knowledge equals understanding its necessitating causes. The second claim, likely to be the more contentious one, but it is merely an extension of the Aristotelian idea that "we know through demonstration", is that it is only within a *societas Christiana* that the meeting of hand and brain yielded experimentally calibrated conceptual elucidation of the universe as experimental science. Christian are the roots of science because it is the christening of the Aristotelian concept of knowledge that explains why empirical science as we come to know it originates in Latin Europe, and nowhere else. This process of christening the Aristotelian knowledge construct, and in the very process transforming it beyond recognition, is clearly at work when Kepler writes, *KGW*, xvi, nr. 448:4-7, that he wants to "provide a philosophy or physics of celestial phenomena in place of the theology or metaphysics of Aristotle". For the Greeks immanent necessity ruled the cosmos and they matched this, to achieve a knowable cosmos, by conceiving of reason as an ordering principle inherent in reality. The most radical formulation of this idea is by Parmenides, ταύτὸν δ' ἐστὶ νοεῖν τε καὶ οὔνεκέν ἐστι νόημα, "thinking and being are the same" (DK fragment 8-34). What Ockham and his fellow nominalist theologians argued for was that God's will, his *potential absoluta*, which commanded the final cause of the Creation, is impenetrable. By severing any link between the final course of reality and its material result, i.e. it's created effect, rational intelligibility of nature became impossible. Nature was ordered by having an order imposed on it instead of the rational being an expression of the immanent order of it. What Anneliese Maier (1967:403) refers to as "the methodological split between theology and natural science" is made possible when the incommensurability between God and man, between *potentia absoluta* and *potential ordinata* is incorporated into epistemology. This requires a realisation that from a human point of view the regularity of the world, its law like nature, is but contingency from the Creator's point of view. It is this contingency that necessitates

the empiricism of science. In terms of the Aristotelian notion of knowledge this means that final causes are out and at best only efficient causes are to be had.

5. Conclusion

Why could only in a *societas Christiana* the trading zone where artisans and intellectual meet each other yield this idea of modern (experimental) science? The Zilselian argument that modern science can be depicted, in the words of (Koyré 1963:852), as "a promotion of arts and crafts, as an extension, as an *ancilla praxi*" is equally unsustainable as the Koyré claim that the likes of Galileo didn't perform any experiments. All I need for now is why the Zilselian argument is flawed.

Artisanal knowledge is skill based and skills are better taught than talked about. This of course reflects that skills are performative actions and can be executed independent of discursive understanding of what one is doing. Because it is skill based, it is learned by mimicking specific behavioural routines, and this requires a desired level of manual dexterity. Because skills, behavioural routines, are central to the craft of the artisans their knowledge is at once a form of knowledge and a form of practice. In other words artisanal is monistic and as such is markedly different form the propositional knowledge conception of the intellectuals which is dualistic. But the dualism so characteristic of the intellectualist theoretical conception of what knowledge is – knowledge is about something that a subject has – is fully dependent upon, comes into existence with, the Greek notion of ἐπιστήμη, epistêmê. From a compararative perspective the crucial thing is that only the European civilisation produced this dualistic knowledge conception (cf. Raven 2015).

Gernet (1980:10) is outspoken that "nothing in the Chinese traditions resembled in the least the radical opposition between the perceptible and the rational". The famed Sinologist Julia Ching is of the same view but she takes it one step further by making the following radical statement: "without any subject/object distinction, there can be no scientific thinking" (1997:244). *Prima facie* Ching, who clearly knows a thing or two about *ru*-thinking, seems to be saying that a Western style dualism is "responsible" for scientific thinking. A provocative suggestion and here is why I think she is right.

The *ru* aren't into truth but are into devising a system of practical morality; in a world-practice that concentrates on acting righteously truth doesn't come into play. It doesn't come into play because of the cardinal Chinese idea of the consanguinity between man and nature and the monism it entails implies there is no higher level of being from which man or nature can be grasp, grasp in a necessarily abstract way that is. (Epistemological worries have no room to life in a monistic model of knowledge.) Comprehending nature and man Chinese style implies showing the manifestations of the reasonableness of life in action.

Ching grasped something of profound importance in understanding the difference between the European and Sinitic civilisations that is relevant for this essay. The point she makes is that because a dualistic knowledge conception wasn't

available in *ru* China the idea of a theoretically, i.e. conceptually, unified understanding of the cosmopolis in the Sinitic civilisation never was on the table. For Westerners of course it is, that is to say Blumenberg (1983:232-3) is right when he writes "the "theoretical attitude" may be a constant in European history since the awaking of the Ionians' interest in nature". This constant is missing in *ru* China and explains the many times observed absence of theoretical explanations in China it. In China the marrying together of practical and theoretical skills into one kind of understanding never could happen.

It is a truism to say that Greek philosophy is close to being co-existent with the idea of *λόγος* (logos), which is best understood as the rational pattern of the world-process, what in German is referred to as *Weltvernunft*, expresses this crucial idea that there is a rational structure to the cosmopolis, and the idea of philosophy is come up with a theory that articulates this immanent structure as best as possible.

This idea of *λόγος*, that the articulation of the rational is an expression of the immanent order of cosmopolis, sits very uncomfortable with the Semitic idea of the world being created by God. This is why the Greek conception of nature had to be replaced by a one that is compatible with Christian assumptions. These Christian assumptions where found in the idea of God as a *Deus Opifex*, superior artisan, who used mathematical principles to construct the cosmos. Because God created the physical universe the cosmos is an intelligible entity cognitively accessible to those created *Imago Dei*.

In his Cecco dialogue of 1605 Galileo (1976:38) casually asks a highly significant question "What has philosophy got to do with measuring anything"? Koyré's notion of "Géométrisation de l'espace" (1939:12-5) is all-important to answer it. By this famous notion is meant a substitution of Ptolemy's concrete and finite space for the abstract infinite one of Euclid. This formulation however hides the radical point Koyré wants to make: "La nature ne répond qu'aux questions posées en langage mathématique, parce que la nature est le règne de la mesure et de l'ordre" (1939:156, Nature replies to questions posed in mathematical language if and only if nature is the domain of measure and order). Geometrization implies measurability. The gist of the Galileo quote is a methodological one, its about a theory of measuring; the readability of nature is due to it being measurable. A measurable nature is quantifiable and hence subject to mathematical treatment. Measuring nature is another word for experimentation, or as Lord Kelvin (W. Thomson) puts it: 'to measure is to know' and as the Dutch say "meten is weten" (measuring is knowing).[18]

[18] The full quote by Kelvin, *Popular Lectures and Addresses*, p. 73-4, is: 'I often say that when you can measure what you are speaking about and express it in numbers you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of *science*, whatever the matter may be'; emphasis in the original.

Attachment

Table 1

Ontology of events	Ontology of principles
Immanence: order realized	Transcendence: order instantiated
Humans are “organism-persons” (Ingold) relating to a cosmopolis, taken up a view by dwelling *in* it.	Human are composites of mind and body apprehending nature by grasping a view *of* it.
The world is an environment constituted through the unfolding relations to a being.	The world is an external nature “waiting to be given meaningful shape and content by the mind of man” (Shalins)
Active interaction is fundamental to the production of knowledge.	Observation - detached contemplation - is the causal bridge between the passive mind of the self and the external world - where the facts somehow manifest themselves.

Difference between the way artisanal knowledge, on the left, and conceptual knowledge, on the right, conceptualise the relation to the cosmopolis.

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