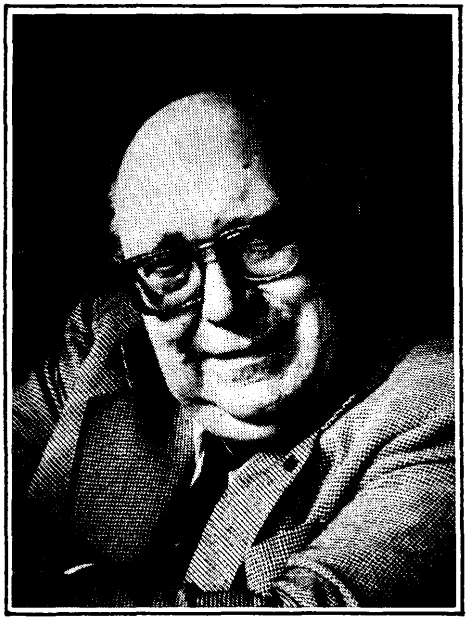

THE LONG AND DIFFICULT TRANSITION FROM PTOLEMY TO COPERNICUS

R.A. Blondeau

Many hypotheses concerning the Creation and world view were already in existence during the oldest civilisations.

Due to a lack of knowledge and insight, these hypotheses became so entangled with magic elements that they are now spoken of in terms of myths and legends. The Ancient Greeks rationalised the presentation of this world view and turned it into an acceptable form.

Sixty years ago, Marnix Gijsen paid an exceptional tribute to the Greeks in his booklet *Oduseus Achterna*. He said, amongst other things : 'It is the duty of every civilised man to be grateful to Greece and its culture. The Greeks taught us to think and reason. They gave us the archetype of every form of art; from the ornamental scribble on pottery to the complete image, the rousing drinking song to the faultlessly constructed drama, the heroic epic to the novel'.

But, he neglected to mention that the Ancient Greeks had also considered every possible variation of every modern scientific theory. From the shape of the Earth, the creation of the Universe, the structure of matter to the evolution in biology.

Several Greek philosophers of physical science attempted to bring the rotation of the celestial bodies into a more balanced system. Clever as some of them might have been, they were all overshadowed by Aristotle!

Aristotle worked following his own philosophical thinking, both in matter and natural position, and in movement. Referring back to Plato and Eudoxus of Knidos, and based more on reasoning than observation, he saw things quite simply. He was convinced that the Universe was made out of perfect geometric shapes : the circle and the sphere. The Universe was, according to him, a collection of concentric spheres which fitted into one another, with the Earth as the stationary centre. The fixed stars were attached to the outside sphere, but the Sun, the Moon and the five known planets had their own spheres. He adjusted their rotational axes and rotation speeds so that they imitated the movements of the celestial bodies as closely as possible.

The movements of the planets were particularly difficult to realize. Although they were all part of the general turning direction, from time to time they slowed down, stopped for a instant, turned back a little and then continued their orbit. In order to follow all these variations as reliably as possible, new rotational spheres had to be added, until there were no less than fifty five.

How the mechanism actually worked is not clear. The spheres were kept in movement by an incorporeal substance and behind the sphere of the fixed stars there was a prime mover. The design had come into being four centuries B.C. and was not completely free of magic and religious elements. But taking everything into consideration, up to that moment in time it was actually the most scientific explanation concerning the shape of the Universe. This system, supported by Aristotle's authority lasted for six centuries.

After more accurate observations of the celestial bodies it appeared that something was wrong with Aristotle's world view. Because the space was limited, adjustments were no longer possible. This was the reason why, in the second century A.D. the Greek scholar, Claudius Ptolemy, eliminated the concentric spheres and created a new design. It was made up of free-moving, circling celestial bodies. Aristotle's mechanical model had to give way to a mathematical theory.

Not much is known about Claudius Ptolemy. He worked in Alexandria — founded by Alexander the Great in the fourth century B.C.

— as an astronomer, a geographer and a mathematician. A sort of university with famous libraries was founded and Alexandria became the scientific centre of the Ancient World.

Ptolemy wrote several studies, amongst which at least three have survived many centuries :

1° The work in which he explains his world system, *Syntaxis Mathematica*, better known as the *Amalgest*;
2° A handbook of geography, *Geographia*, from which the first printed Latin translation was published in Italy in 1475;
3° *Tetrabiblos*, the basic book of astrology. This claims that the stars have an influence on the character, behaviour and events in a person's life. This latter work is still used in some circles.

When developing his world view, Ptolemy kept to the main basic principles of Aristotle which were :

- The Earth is the stationary centre of the Universe;
- All movements are circulative.

However, Ptolemy's elaboration was not only more refined, it was more in accordance with the phenomena. It was more logical, deeply thought out, and far more complicated — particularly concerning the orbits of the planets.

The Sun and the Moon orbited the Earth in a simple circle, while the planets were placed on smaller circles, the epicycles. The centre of the epicycle also orbited the Earth. This way Ptolemy knew more or less how to deal with the strange regressive movements of the planets.

This system of epicycles, in which the centre ran through a bigger circle was called a deferent but was not Ptolemy's invention. It had been thought up much earlier by the mathematician Appolonius of Perga, who laid the foundation for the study of conic sections.

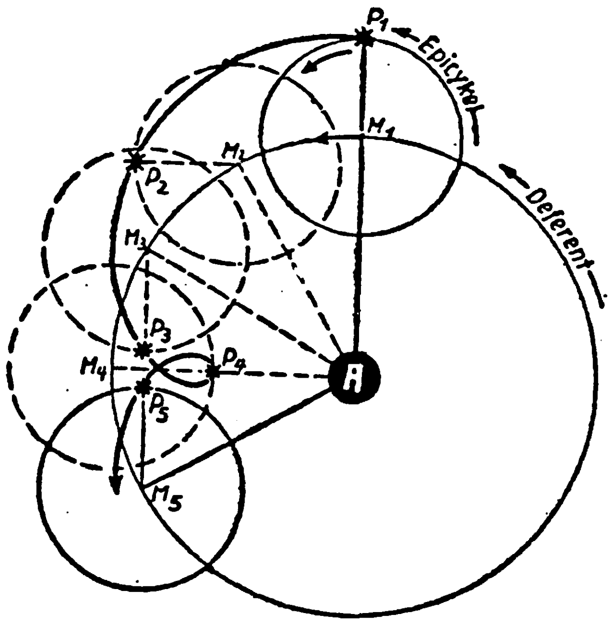

Fig. 1 : The system of Ptolemy. Planet P moves on the epicycle; Centre (M) of the epicycle moves on the deferent around the Earth.

These epicycles alone were not enough to be able to follow all the movements and changes in size and luminosity of the celestial bodies. Therefore the centre of some circles had to be placed 'offcentre' from the Earth, they in turn described a circle which also had its own eccentricity. The reader will be spared any more circles and complicated movements, but it must be pointed out that Ptolemy needed 42 circles, twisting and turning within each other, in order to follow the Sun, the Moon and the five planets.

When Ptolemy published his world view, Greece had become a Roman province only a couple of years earlier. The Romans took over many ideas from the Greeks, but they did not produce any scientists who worked on Ptolemy's system. After the fall of the Roman Empire, during the fifth century, the barbarians spread like a destructive flood over

Europe. With the advent of the Merovingians and the Carolingians a slow progress towards our own civilisation started but nothing was known about the written and scientific studies of the Ancient Greeks.

The Arabic civilisation, which had adopted many ideas from the Greeks, accepted Ptolemy without question. When, in the 9th century, Mohammedan knowledge and learning was dying in the East, in the West it was enjoying a revival. The movement started in Spain, in the cities of Cordoba and Toledo.

There was a great interest for Arabic learning growing in Europe and soon a stream of classical books was being translated from Arabic into Latin.

Ptolemy's work had already been translated into Arabic by Gerardus of Cremona in 1175, so it was available for the Western world. It is not known to what extent this translation was distributed — in those days printing had not yet been invented — but the Western World must have known about Ptolemy's system because so many doubts had been voiced by sceptics from the 12th to the 15th century. Some of them had more admiration for Aristotle's concentric spheres than for Ptolemy's complex circles.

This point of view can be illustrated by a typical quote from King Alphonse X of Castile. Whilst attending an astronomical congress, halfway during the 13th century, it is said that he was rather condescending about Ptolemy's system : 'If God had asked me for advice during the Creation, it would have been a lot simpler!'

Even though the great Dominican theologian and philosopher Thomas of Aquino had introduced Aristotle's philosophy into the learning of the church, and had declared himself radically in favour of the geocentric system — or more specifically the antropocentric system — and even though he had been canonised in 1323, it was actually two priests who, in their writings in the 14th and 15th century, first mentioned a moving Earth in order to explain the celestial phenomena.

Nicolas of Oresme was one of these priests. In the 14th century he lectured in Paris and later became Bishop of Lisieux, and in the 15th century more importantly there was Nicolas Cusanus.

Cusanus, who became a Cardinal, was born in Kuss — which explains his name — situated on the left bank of the river Mosel, between Trier and Cochem, opposite Bernkastel. Cusanus was a versatile man and in his thinking he could be considered as a typical transitional figure (stepping stone) between the Middle Ages and the New Age, between the mystic and physics. He not only wrote a series of philosophical and theological works, but also dealt with subjects in physics : movement, weights and measures. He compiled a map of Central Europe and collected astronomical instruments, including a celestial globe, which is said to be the oldest in Germany.

Together with many manuscripts and incunabula these instruments can be seen in a wonderfully restored library, in the St Nikolaus hospital, a home for the aged that he founded in 1458. This institution could house 33 old people (from the age of 50 onwards in those days). Everyone in the home was entitled to a daily ration of half a litre of Mosel wine. The wine came from the family vineyard of the Cardinal. This must have been a very efficient and highly appreciated geriatric treatment, long before geriatry was acknowledged as a medical discipline.

Even though Cusanus strongly distanced himself in his writings from the certainty which surrounded the existing cosmological ideas, but only in vague terms, his opinion was that the Earth was a star and it moved just as the other stars did, but he gave very few details. In one of his pamphlets, probably in 1444, he did state that the Earth turned on its axis, but there was no mention of a yearly rotation around the sun.

Cusanus is presented as the predecessor to Copernicus. This is rather an exaggeration. In fact Copernicus did not have a predecessor. He was unique. Where others suggested in a few sentences that the Earth moved, he gave the system a geometric shape — accurately calculated in all its consequences. His work comprised more than 200 pages of text and 146 explanatory geometric drawings.

Nicolas Copernicus was born in 1473 in the town of Thorn. Thorn was in fact a West Prussian city, but seven years before his birth, West Prussia had become a Polish province. His father, grandfather and great grandfather were actually born in Krakow, so it could be said that he was Polish.

He lost his father when he was ten and was brought up by his mother's brother, a priest who later became a Bishop. He studied mathematics and astronomy at the University of Krakow and then went to Italy where he enrolled at the University of Bologna. He continued to study the same subjects for four more years and also became proficient in Greek grammar. He then went to Ferrara to obtain a degree in ecclesiastical law and afterwards to Padua to study medicine.

At the age of thirty four he returned to his homeland where, for six years, he acted as secretary and personal physician to his uncle who, in the meantime, had become Bishop of Ermland in Heilsburg. Whilst working for his uncle, he devoted himself to astronomical observations and studied many classical works on astronomy.

Thus Copernicus was a scholar in astronomy, medicine and the law. Until the late 17th century there was a strong affinity between astronomy and astrology and medicine. It was believed that the stars and constellations had an influence on limbs and organs and so the position of the celestial bodies was consulted in diagnosis and prognosis of the sick. It must not be forgotten that in 1430 *astrology* was taught as a science at the University of Louvain, by Professor Jan van Wesel, Doctor of Medicine and great grandfather of Andreas Vesalius. One hundred and fifty years later Pope Sixtus V issued a papal edict in which he condemned astrology, but permitted astrological predictions as long as they only concerned the weather, agriculture and health!

During the years that Copernicus was secretary to the Bishop of Heilsberg, his heliocentric world system began to take definite shape. In the dedication to Pope Pius III in his master-work (which would be published more than thirty years later) he said he knew, through studying the writings of the old philosophers, that they had varying opinions over the question of whether the Earth was in movement or not. His professor of astronomy in Bologna, Dominico Maria di Novara, who also dared to think that the Earth might move, obviously had a great influence on his work.

Before 1514 (the precise year is unknown), he wrote a short dissertation, in which he developed the most important points in his heliocentric hypothesis. This dissertation was not printed, but copies of it were sent to friends and acquaintances and then handed down throughout the years.

There was no response to the first dissertation. It not only propounded the unlikely suggestion that the Earth orbited the Sun, a fact that was unsubstantiated but it also contained serious astronomical mistakes.

Copernicus spent many more years adjusting his system with the help of his latest findings and observations. After his uncle's death in 1512 he moved to Frauenburg where he became a canon at the cathedral.

In 1539, Georg Rheticus, a young German scholar, visited Copernicus in order to become familiar with his theories. Rheticus was a protestant and a professor at the University of Wittenberg where Luther had started the Reformation twenty years before.

Two months later Rheticus wrote a compact summary of Copernicus' work — the *Narratio Prima* — and had it printed in Danzig in 1540. This short essay had a certain popularity and was reprinted in Basle the following year.

In the meantime Copernicus had finished his master-work on the rotation of the celestial bodies. He kept this a deep secret because he was afraid of the reactions it might cause.

Earlier, in 1539, Luther, who had heard about Copernicus' work remarked in one of his after-dinner speeches : 'This fool will reverse the whole art of astronomy, turn it upside down; but in the Holy Scriptures it is written that it was the Sun and not the Earth that Joshua commanded to stand still.' Above all there was Copernicus' own uncertainty. This uncertainty must have been present despite what was later claimed and this is understandable when one realizes that he was the first to be diametrically opposed to the doctrines of Aristotle, Ptolemy and the holy Thomas of Aquino. Doctrines which had dominated for centuries.

He had no hard evidence for his system, but based it on the fact that the movements in the Universe were easier to explain if one assumed that the Earth and the Planets orbited the Sun and that the Earth rotated around its axis every twenty-four hours. For the rest he only had aesthetic thoughts, which he noted as follows (page 9 of his book) : 'Seated in the middle is the Sun. Who would wish to move this lamp to another place in this beautiful temple from which she spreads her glowing light? The Sun, as if seated on a royal throne, rules over a family of celestial bodies who orbit around her. We find through this positioning a remarkable balance in the world and a harmonious link, which cannot be achieved in any other way.'

As a result of the success of Rheticus' compact summary, Copernicus decided to publish his master-work after all. The task of supervision was again entrusted to Rheticus who, in 1542, had been appointed professor in Leipzig. He, in turn, passed on the supervision of the publishing and distribution to his friend Andreas Osiander, a well-known Lutheran theologian. It was printed in Neurenberg and appeared in 1543. Copernicus would have received a copy just before he died on May 24th of that year.

The work consisted of six "books", in the sense that each book was a chapter. It began with a preface entitled : *To the reader concerning the hypotheses in this work*, in which is written : 'These hypotheses are not necessarily true or plausible, it is sufficient that they make the calculations possible and that they produce results which are in accordance with the observations.'

At first this preface appeared to have been written by Copernicus himself. It was not signed separately and clearly formed an integral part of the work. But the ideas presented in the book were seriously weakened by this preface, because of its content which was full of hypotheses and implausibilities.

In the first book Copernicus deals with the sphere, the shape of which characterizes all the celestial bodies and within which, he believed a rotating axis was intrinsic. He goes on to clearly describe the heliocentric system, which he invented :

- He places the Sun in the centre and allows the planets and the Earth to describe a perfect circular orbit around it. Only the Moon orbits the Earth. The Sun and the far distant field of the fixed stars are stationary.
- He demonstrates that the movement of the Earth when it orbits the Sun causes the moving planets to be seen from different angles from which the apparent strange regressive movements originate. In his system he did not need Ptolemy's epicycles to explain these movements, therefore it became much simpler.

Those who think they know everything about Copernicus' work after having only read the first book will become extremely enthusiastic about the simplification of the heliocentric model. Many readers of Copernicus have not actually got further than the first book because the following books are considered as an explanation for mathematicians, written in stiff, difficult language, containing many geometrical arguments.

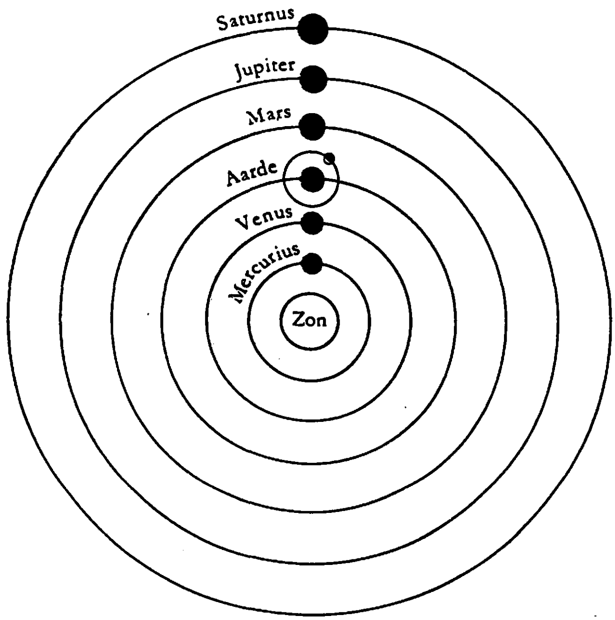

Fig. 2 : This diagram is taken from Copernicus' first book. It represents his system in a simplified way.

In these books, where all the observed movements are described in detail, an extremely complicated construction is presented. In order to follow all the movements and deviations in the firmament as correctly as possible, Copernicus, amazingly enough had to use again the epicycles and eccentricities.

Whereas Ptolemy needed 42 circles, Copernicus finally ended up with 38, so the simple, attractive image of the first book was effectively destroyed.

In some history books the impression is given that — with the appearance of Copernicus' work in 1543 — a turning point in scientific thinking was reached and that this happened overnight. This was far from the truth! The transition from Ptolemy to Copernicus, more specifically from the geocentric to the heliocentric thinking, was a slow and difficult process, even after 1543!

De Revolutionibus Orbium Caelestium. This is the title of Copernicus' work and about a 1000 copies would have been printed. But the circulation took place so slowly that, for a long time, Ptolemy's system was hardly affected.

On February 23rd 1547, about four years after the appearance of Copernicus' work, the Flemish cartographer, Gerard Mercator, wrote a letter to one of his patrons, the Bishop of Arras. This letter dealt with the magnetism of the Earth and the magnetic pole. In his explanation it can be seen that he adheres to the theory that the Earth is the centre of the Universe.

Mercator made geographical maps, astronomical apparatus, terrestrial and celestial globes, and was in touch with geographers and astronomers. He lived and worked in Louvain in the shadows of the university and must certainly have known about Copernicus' system yet he did not even mention it. Just like all the other scientists, he ignored it.

Indeed Copernicus' hypotheses were not accepted as reality because they conflicted with day to day experiences. The same arguments as those which Aristotle had put forward eighteen centuries before — in which he had refused to accept a rotational Earth — were still in use.

The rotation of the Earth around its axis every 24 hours was not compatible with the stability of buildings. A bird flying independently from the rotating Earth but in the same rotational direction, would not progress but fall behind. A stone dropped from the top of a tower would not land at its foot but, because of the rotation of the Earth, end up somewhere westwards of the tower.

The movement of the Earth around the Sun also caused confusion. If two stars were observed on a particular day, they could be seen at a certain angle. But six months later, after the moving Earth had completed half an orbit and was approaching these stars, they could be seen at a greater angle or parallax, creating the impression that they had diverged. Take an avenue of trees as an example : upon entering it, in the distance the trees look as if they were planted touching each other, but upon penetrating deeper they diverge.

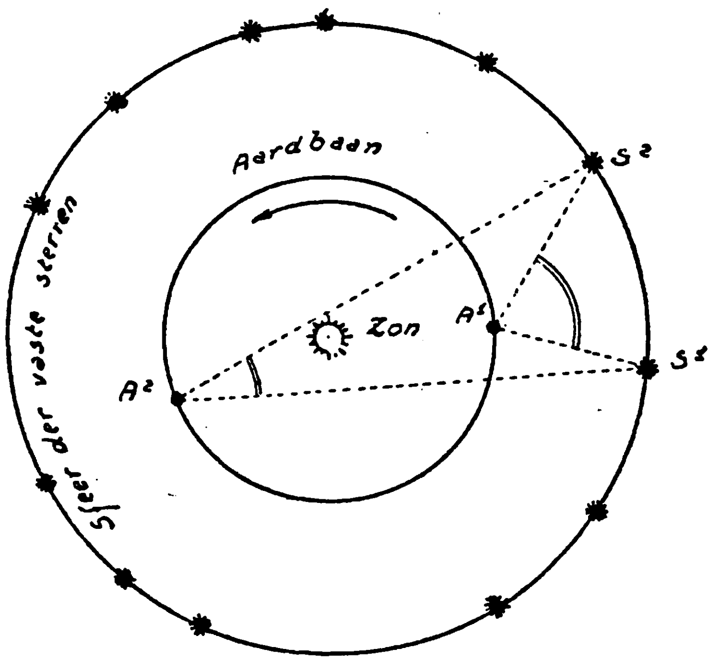

Fig. 3 : Stars S1 and S2 are seen from the Earth at a certain angle. This angle is bigger when the Earth is closer to the stars.

Because none of these consequences were determined and were contrary to the theory — the theory was completely ignored. Indeed, Copernicus pointed out that no parallax with the fixed stars could be established, because the sphere of these stars was too far away. It was not believed that there could be such an unbridgeable and enormous gap between the last planetary orbit — in those days Saturn's orbit — and the sphere of the fixed stars.

Nevertheless Copernicus' explanations were considered as an ingenious piece of work and his numerical values were the result of patient observations and exact measurements. These numerical values soon became the base of new astronomical tables, but the final conclusion, the renewed vision that the Sun instead of the Earth, was the centre of the Universe was not pursued.

Copernicus' book was not successful. Even though the original version never sold out, 23 years later in 1566 there was a reprint in Basle. Somebody obtained a copy of Copernicus' work and on his own initiative had it reprinted, including all the original mistakes and a whole series of new ones. In those days there were no authors or publishing rights.

It is interesting to compare the situation concerning the publication of other astronomical books in those days. The basic handbook of astronomy, *De Sphaera*, was written by the Englishman Sacrobosco about 1230 and was based on Ptolemy. There were no less than fifty nine printed editions until the end of the 17th century. Clavius' commentary on this work was published in 1570 and was reprinted nineteen times during the following 50 years. Between 1472 and 1600 Ptolemy's *Amalgest* and its corresponding planetary theory by Peurbacht was reprinted about forty times in Germany alone. In the first seventy five years Copernicus' work was reprinted only once!

Not only did the scientists view Copernicus' work unfavourably, but religious circles refused point blank to accept it.

Even before the appearance of his work in 1542, Copernicus' system was condemned by the University of Wittenberg. Others would follow this example : in 1553 the University of Zurich, in 1573 the University of Rostock, in 1576 the Sorbonne and in 1582 the University of Tübingen.

The Catholic Church — which did not interpret the Bible as literally as the Protestants — was, in the beginning, quite sympathetic towards Copernicus. It was only after the Trente Council — the counter Reformation council — that they began to observe every variation very closely. The Order of Jesuits was very active in this matter. In 1581 the German Jesuit and astronomer Christophorus Clavius questioned not only the physical absurdity of the system, but also the fact that it conflicted with several passages in the Holy Scriptures.

Then another figure appeared on the scene. The Danish astronomer Tycho Brahe who was born a few years after the death of Copernicus.

Brahe was the most superior astronomer who had existed up to that time, because for more than thirty years he had systematically observed the Heavens. He was very ingenious in the construction of precise measuring instruments and was Copernicus' opponent both on scientific and religious grounds.

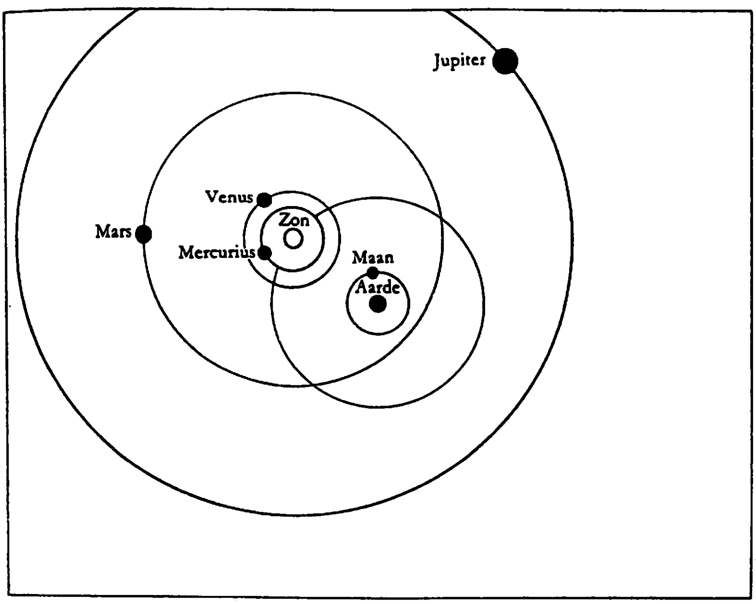

Fig. 4 : The system of Tycho Brahe. The Moon and the Sun orbit the Earth, the planets orbit the Sun.

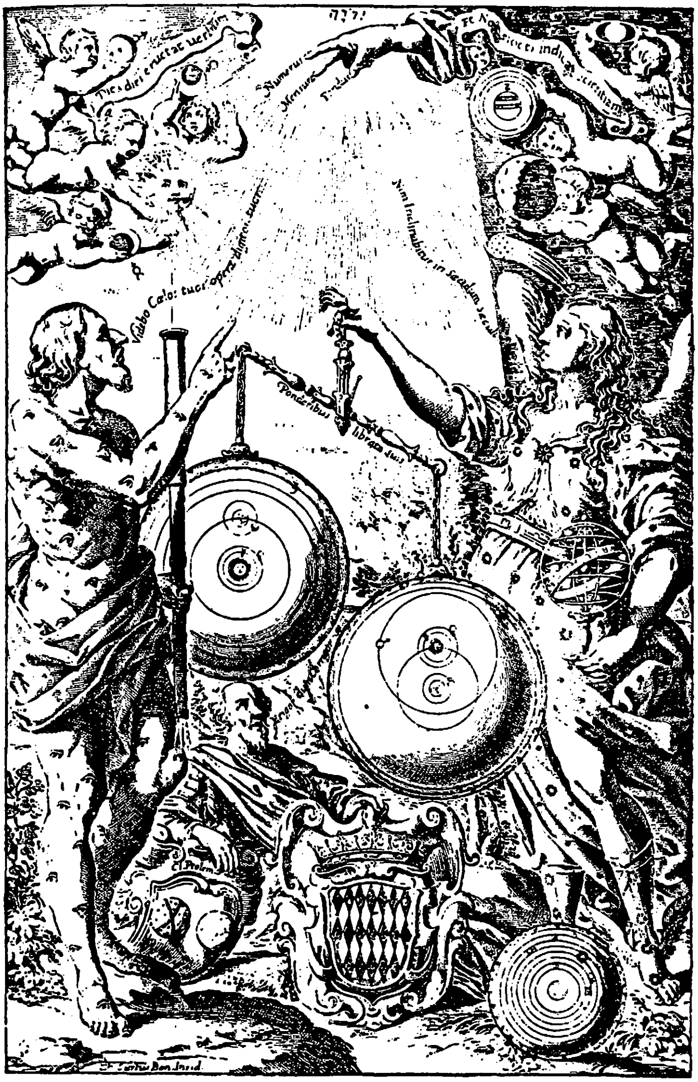

Fig. 5 : Engraving from *Amalgestum Novum* by J.B. Riccioli (1651). Urania, the muse of astrology, balances the system of Copernicus against that of Tycho Brahe. Copernicus' is found to be too light. At the bottom lies the rejected system of Ptolemy.

His opinion was that the cumbersome heavy Earth could not possibly be a fast-moving celestial body, but the Sun and the planets were more likely to be because they appeared almost as weightless lights. In addition, there was no change in parallax in the stars so this led to his conclusion that the Earth certainly was not orbiting the Sun. This was why, forty years after the publication of Copernicus' system he decided to develop his own world view.

This world view was a sort of compromise solution. It went halfway towards accepting Copernicus' system — that all the planets, except the Earth, orbited the sun. At the same time it also related to Ptolemy, in that the Sun together with the planets, orbited the Earth whilst the Earth stayed a non-moving centre.

Nowadays Brahe's system is only mentioned in passing, as if it had never had any meaning and is only considered as a curiosity, used to tide over temporarily the mental leap from Ptolemy to Copernicus.

In a wide historical context this is indeed so, but in the 17th century Brahe's world system was dominant.

Many facts are witness to the uncertainty of the views in those days. For instance Dr. Nicolaas Mulerius, of Bruges, was the first Professor of medicine and mathematics at the University of Groningen, which was founded in 1614. He was responsible for the third printing of Copernicus' work *De Revolutionibus Orbium Caelestium.* Mulerius prefaced this edition with a complete commentary which, strangely enough, reduced the heliocentric system to shreds.

Meanwhile there were some who still adhered stubbornly to Ptolemy. In 1605 Justus Lipsius, the great classic philologist, asserted that the abdication forced upon King Alphonso X of Castile by his son, and who had roundly criticised Ptolemy's system, was to be considered as a punishment from God because he had been so insulting about Ptolemy.

Had Copernicus any followers? One could be forgiven for asking. Actually there was one. Gemma Frisius who assembled globes and astronomical instruments in Louvain. He not only received a copy of *Narratio prima*, he also studied Copernicus' master-work and had quoted from it in a personal treatise in 1545. In February 1555, three months before he died, he expressed his enthusiastic acceptance of Copernicus' views in a letter to one of his students.

As well as Gemma Frisius there were some free-thinking minds who dared to break with the scientific and religious authoritative tradition. Giordano Bruno was one of them and because of his differing opinions he was burned at the stake. Later came Galileo, who was also very difficult to keep under control.

In 1609 Galileo was the first to point a modest, home-made telescope at the firmament and find out that there were four satellites orbiting Jupiter. This proved that the Earth was not the centre of all circular movements and thus lent weight to Copernicus' teachings.

In 1613, Galileo published a work in which he came out openly in favour of the accuracy of Copernicus' system. He went to Rome to plead the case, but was not able to prevent a commission of theologians from condemning the theory of a double Earth movement as being in conflict with religious belief. In 1615 Copernicus' book was confined to the Index of forbidden books and the following year Galileo was forbidden to teach the system. Thus, with these decisive actions the Catholic Church showed that Copernicus was officially banned.

The protestants also found it hard to accept. Simon Stevin, who had left Flanders in 1581 and went to Northern Holland, appeared to be a supporter of Copernicus, as was mentioned in his *Wisconstige Gedachtenissen* which was published in 1608. He even corrected Copernicus regarding the Earth's movements. In Holland, where there was much more tolerance, he did not have much to fear. Nevertheless Professor Struik, the eminent historian of mathematics, did suggest that the highly appreciated Stevin should not be appointed as a professor at the School of Engineering in Leiden because of his so-called Copernican heresy.

Filip van Lansbergen from Ghent, who had studied mathematics in England, became a reformed clergyman in Antwerp and after the fall of the city in 1585 emigrated to the North. There he was expelled from office as a clergyman in 1613. The reason for this dismissal was that he supported the principle of "the static Sun and the moving of the Earth". In 1629 he wrote a piece in which he defended Copernicus' system, but was reprimanded by professor Libert Fromondus of Louvain.

Copernicus' greatest defender should have been Joannes Kepler. Kepler was an astronomer and the successor to Tycho Brahe at the court of Rudolph II in Prague. Not only was he a great admirer of Copernicus, he even corrected his system by proving through his three laws of planetary motion, that the planets moved in elliptical paths around the Sun and followed well-determined speeds. These laws, published in 1609 and 1619, were slow to be understood because they were actually hidden under an excess of calculations and mythical considerations. These were oriented towards building up a sort of harmonious world order, supported by a complicated geometrical foundation. When Galileo died in 1642, he had no knowledge of Kepler's laws, although both scientists regularly wrote to each other!

Giovanni Domenico Cassini, professor of astronomy in Bologna, was invited to go to Paris on the invitation of Minister Colbert in 1669 to establish a national observatory. He was a man who had made notable astronomical discoveries, but when he died in 1712, he knew nothing about Kepler's laws, he had ignored Copernicus completely and throughout his life stayed an adherent of Ptolemy.

Michael Floris from Langeren was a cosmographer and mathematician to the Spanish king in Flanders and he had a plan to found an observatory in the castle of Gaasbeek about 1640. Nothing came of this, but he did construct a remarkable planetarium which was unsuccessful and very unpopular because, being based upon Copernicus' system, it was considered an unreal fantasy.

In 1644 and 1653 the Flemish priest Godfried Wendelen from Herk-de-Stad, defended Copernicus in his writings, even though he knew that in 1616 Galileo had been forbidden to support the system and was forced to renounce it. But Wendelen's was only a weak voice and he was looked upon strangely by the rest of the fraternity.

In 1651 the Jesuit Giovanni Batista Riccioli, a professor of philosophy, theology and astronomy in Bologna, published a work in two parts, *Amalgestum Novum* — a voluminous summary of the astronomical knowledge of those days — in which he produced 77 pieces of evidence against Copernicus' system and only 49 in favour.

In 1689, Jan Luyts, a professor at the University of Utrecht, published another work on astronomy, in which he completely rejected Copernicus' system. And two years later, in 1691, Martijn van Velden, who was a professor at Leuven and appeared to be a supporter of the heliocentric system, was ordered by the Principle of the university — after a long and exhaustive lawsuit — either to change his thesis or scrap it altogether.

It was about 40 years later — in the 18th century — that the first positive proof that the Earth moved appeared. In 1726 James Bradley, who was a professor at Oxford, determined the aberration of starlight, which is the inclined incidence of light rays in a telescope. This can only be explained if it is accepted that the Earth is moving very fast.

This was the beginning of the turning-point. Slowly Copernicus began to be accepted, two centuries after the appearance of *De Revolutionibus Orbium Caelestium*. In 1791 the Italian astronomer Giovanni Batista Guglielmini dropped a metal ball from the 78-meter Asinelli tower in Bologna. The deflection of the ball as it fell proved convincingly the Earth's rotation.

Even so, on May 5th 1829 in Thorn, when a monument was erected in honour of Copernicus opposite the house where he was born, the clergy of the town refused to take part in the festivities, because his book was still on the forbidden Index. But it did not stay there much longer as it was removed in 1835.

To cap it all, three years later the German astronomer Friedriech Wilhelm Bessel from Koningsbergen ascertained a difference in parallax with a star from the constellation of the Swan. In 1851 the French physician Léon Foucault proved the rotation of the Earth once again in the Pantheon in Paris with his renowned pendulum experiment.

In 1854, in Warsaw a triumphant new edition of *De Revolutionibus Orbium Caelestium* was published as a tribute to the great Polish scientist. In this edition it was mentioned for the first time that the preface, in which Copernicus' system is portrayed as a hypothesis, was not written by Copernicus himself but by Andreas Osiander, who had been responsible for the initial printing.

This was based upon rather dubious proof that might have come into Kepler's hands. Earlier there had never been any mention of it, because Copernicus was considered as a questionable case. But now he was considered as the great visionary who had advanced the Earth's path three centuries before. It could not be shown that he had ever been unsure or doubted himself. A great man is great in any field. And that is how it was going to be. That is how history is written.

During the 19th century the paths of the planets were calculated precisely by using high mathematics. Today the results have been confirmed brilliantly by space travel.

The question could be asked whether this final result is not enough and if it makes sense to try and unravel the thinking and doubting which was a part of the construction of our world view.

The answer to that in the words of the philosopher is : 'If we really want to understand something, we should go back to its origin'.

But in order to end on a more poetic note, here are the words of the Dutch historian Johan Huizinga :

It is good for he who progresses
through the wind of centuries,
to stop for a little while
and look back to the place
which he left in the morning!