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SCIENTIFIC CONTACTS AND INFLUENCES BETWEEN THE ISLAMIC WORLD AND EUROPE: THE CASE OF ASTRONOMY

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When, in the early seventh century AD, in the Arabian Peninsula the new religion of Islam was founded and developed, the conditions for its meeting with the Christian world were significantly different on the two sides. The inhabitants of the lands of the Middle East and of Arabia were accustomed, since centuries, to live together with Christian and Jewish communities and individuals. The Muslims, therefore, had no major difficulty, after the spread of Islam through the lands of the Middle East and North Africa, to tolerate the Christian and Jewish minorities and to coexist with them peacefully. The situation was basically different on the side of the Western, Christian, world. The Christian world, at that time, existed in a sharp dichotomy: in the East, the Byzantine, orthodox, empire, and in the West the Roman-Catholic, Latin, area, falling into many separate dominions.

The Byzantines knew their oriental neighbours for centuries; they knew them as occasional invaders or aggressors on the South-Eastern borders, but they also concluded treaties and entertained friendly relations with some of their tribes. It took them a while to realize that the Muslim expansion and conquests meant more than just some local raids and that behind all that there was a firm ideology, a new religion of its own. The report of Theophanes Confessor (d. 818) in his chronicle about these developments reached the Latin West, where it was used by Anastasius Bibliothecarius (d. 897) in his chronicle *Historia tripartita* and conveyed to the West the Byzantine attitude towards the new, "heretic", religion promulgated by the Prophet Muhammad.

The Latin West was in the eighth century a uniform area of Christian, Rome-centred, belief. Apart from few Jewish groups or individuals, it was a closed Christian society living in the solid conviction of the validity and prevalence of its belief, without the experience of having in its mid adherents of other beliefs. This situation of Christian self-confidence was suddenly shaken by the invasion of the Muslims in Spain, in 711. Here the Latin West was confronted not just with one of the not uncommon attacks of some people, but with the adherents of another belief contesting the uniqueness of their background: their belief. At that moment a basic hostile attitude of the Christian West toward Islam was formed which continued through many centuries, and one might even say, somehow until today. The role played in the first centuries by the Arabs - the "Saracens" or "heathens" - (and, for the Byzantines, by the "Persians"), was later taken by the Turks conquering parts of South-Eastern Europe and threatening even Vienna.

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But it would be wrong to assume that the two worlds lived on through the centuries in continuous enmity. There developed contacts beyond the borders on many levels. Christian pilgrims visited the holy places in Palestine; commercial contacts were established and firm establishments of Western traders were set up in several cities in Islamic lands; embassies were exchanged between the two sides and treaties were concluded. These contacts and exchanges led to a deeper mutual understanding. By and by each side learnt of the achievements of the others and became interested enough to procure for themselves what appeared valuable or useful to them. Not the least of the subjects provoking interest on each of the two sides were the sciences, in the widest sense. So it came that at different times, in different directions, vast movements of scientific borrowing developed. In the following we shall deal with such contacts and borrowings in the field of astronomy, which was always closely related to mathematics and which usually also, comprised astrology (the strict separation between astronomy and astrology was only introduced in Europe in early modern times[1]).

With the spreading of Islam through the lands of the Middle and Near East the Arabs came into contact with the inhabitants of the area and began to learn of their achievements in all fields of civilization, among which there was also what had been cultivated there of the remnants of Greek science. As it seems, not only scholarly texts had there been preserved and studied, but also astronomical instruments from Greek tradition such as the celestial globe and the plane astrolabe had survived.

Perhaps the oldest evidence in this context is the cupola of the caldarium in the desert castle of Qusayr 'Amra (ca. 60 km. east of Amman) built under the Omayyad Caliph al-Walid I (r. 705-715). This cupola is decorated with the painting of the celestial vault showing a number of constellations and some of the basic great circles in the sphere. As has been observed, this representation of the sky was copied from a celestial globe, naturally of Greek origin; but the artists, being no scholars themselves, committed the error of copying the view of the sky as it appeared on the convex, outer, surface of the globe onto the concave, inner, surface of the cupola so that it appears contrary to the natural view in the sky[2]. Another evidence for the existence of a Greek celestial globe in the area in the eighth century is found in Ibn al-Salah's (d. 1154) treatise on the mistakes in the transmission of Ptolemy's star catalogue in the *Almagest;* he cites a book describing a Greek celestial globe *(kitab fi iqtisas kura yunaniya)* which, as can be gleaned from the precession value cited, would have been constructed around 738 AD.[3]

Also for the plane astrolabe it must be assumed that exemplars from the Greek tradition survived into the early centuries of Islam and conveyed to Muslim scholars its actual form which they might not easily have been able to develop merely after the written texts on the construction of the instrument. Unlike the celestial globe, no specimens or mentions of such exemplars are known; the only Greek, Byzantine, astrolabe known dates from 1062 AD and may reflect oriental influence.[4] It should, however, be pointed out that in 662, a few decades after the Arabic conquest, bishop Severus Sebokht of Qinnasrin (south of Aleppo) wrote a treatise, in Syriac, on the astrolabe based on Greek sources; this proves that the knowledge and practice of the astrolabe were alive in the area in the seventh century.

[1] Hübner 1989.
[2] Saxl 1932; Beer 1932; Brunet, Nadal, Vibert-Guigue 1998.
[3] Ibn as-Salah 1975, 18, 72f., 132 (Arabic).
[4] Dalton 1926; Stautz 1997, 40f.

The most famous manifestation of the interest of the Islamic world in the sciences of the Greeks, and of pertaining mutual contacts, is formed by the translation movement beginning in the eighth and continuing into the tenth century. Of the innumerable scientific texts then translated into Arabic we shall here only deal with astronomical and astrological materials. In the early period several Greek texts, especially in astrology, were translated from Middle-Persian versions. Afterwards Syriac was often involved, because practically all of the translators were Christian clerics and scholars well versed with Syriac. Among the works translated,[5] the most influential was Ptolemy's astronomical handbook (ca. 150 AD) *Mathematike Syntaxis,* known with the Arabs - perhaps after a Middle-Persian form - as *al-Majasti,* which later became the famous Latin *Almagest.*[6] Of this work three successive translations were produced; the last one, by Ishaq ibn Hunayn, was revised by Thabit ibn Qurra. Traces of the first translation can still be found in al-Battani's *al-Zij al-Sabi*[7] and in the treatise of Ibn al-Salah.[8] Two of these versions arrived in Muslim Spain where, in the twelfth century, they served as the basis for the Latin translation by Gerard of Cremona. Still in 1732 Jayasimha, the Maharaja of Amber (India), had a Sanskrit translation of the *Almagest* made from its Arabic recension *(Tahrir)* by Nasir al-Din al-Tûsî (composed in 1247).[9]

These translations were normally instigated and patronized as well by influential private persons as by viziers or the caliphs. The outstanding figure here is the Abbasid caliph al-Ma'mun (r. 813-833), who is known as the sponsor of two translations of the *Almagest,* apart of many other works. Following the example of the Khizanat al-Hikma, an institution collecting books and promoting the acquisition and promulgation of the sciences instituted by his father, the caliph Haran al-Rashid (r. 786-809), he founded in 832 the Bayt al-Hikma, "House of wisdom", with the same aims.[10] It is also said that in pursuit of Greek scientific manuscripts he" sent a delegation to the Byzantine emperor. One of the most famous translators, Hunayn ibn Ishaq (808-873), is reported to have once spent two years, presumably in Byzantium *(Bilad al-Rum),* in order to improve his knowledge of Greek and that, on his return to Baghdad, he was able to recite verses from Homer's epics in Greek.[11]

The influx of Greek science into the Islamic world was of far reaching influence, not only for the formation and growth of Arabic-Islamic science itself, but later also for the medieval scientific "Renaissance" in Latin Europe. Already under al-Ma'mun - when the translation movement was still far from having come to its end - Arabic astronomers began to examine, to criticize and to improve parameters from the Greek tradition, notably in the *Almagest.* From now on Arabic-Islamic astronomy started its own life to flourish for many centuries. At its base there was the knowledge of the Greeks, the geocentric cosmic system of Aristotle and Ptolemy. And Arabic-Islamic astronomy remained Ptolemaic-geocentric through all times, apart from a few individual proposals of other models which, however, did not gain wider acceptance. But Arabic-Islamic astronomers more and more improved their observations of the motions of the celestial bodies and devised ever more refined methods to bring the observed phenomena in harmony with Ptolemy's model of the world.

Another, similar, process of scientific contacts and borrowing developed in Europe, now in the opposite direction, from East to West, from the late tenth to the thirteenth centuries. Again, innumerable scientific

[5] For individual Greek authors and texts translated into Arabic, see Ullmann 1972, 277-297; Sezgin 1978, 68-113; Sezgin 1979, 30-76.
[6] Kunitzsch 1974a, 115-125.
[7] Kunitzsch 1974b; Ibn as-Salah 1975, 97-105.
[8] Ibn al-Salah 1975.
[9] Kusuba - Pingree 2002, 5.
[10] Sourdel 1960, 1141.
[11] Strohmaier 1971,578-581.

texts were translated, now from Arabic into Latin and some also into Old-Spanish and Byzantine Greek. After the Muslim conquest of the territories along the southern and western coasts of the Mediterranean, parts of Europe came into direct contact with the Arabs. Most of the translations of this period were made in Spain, but some also in Sicily, in the Crusaders lands in the Near East and in Byzantium.

The Arab conquest of Spain began in 711, and soon most parts of the Iberian Peninsula were under Arabic rule which lasted for almost eight hundred years. In the course of this span of time the area governed by the Arabs continuously shrunk, one part after the other being regained by the Christian *reconquista,* until in 1492 the last Arabic principality, Granada, was captured by Ferdinand of Aragon and Isabella of Castile. Spain thus fell, in those centuries, into two parts, a southern part, al-Andalus, under the rule of many successive Muslim dynasties, and the northern, Christian, part, both parts continuously in motion, the Christians extending their dominion more and more southward. The Christian population of al-Andalus continued to live under Muslim rule. This *convivencia* was not free of problems; the reports of various sorts of oppression are numerous. At least, the Christians of al-Andalus more and more accustomed to the leading Arabic culture. Paulus Alvarus complains, in the ninth century, about the behaviour of the young Christians who neglect their own Latin culture and try to excel in the refinements of the Arabic language and even Arabic poetry.[12] The "Arabized" Christians of al-Andalus were called Mozarabs *(musta'rib),* and individuals from this group were often helpful in the transfer of knowledge from the Arabian side to the Christians. It must be stressed here that all the translations of scientific texts from Arabic were always made in the Christian parts of Spain.

After the consolidation of the Arab rule the Arabs of al-Andalus became also interested in the sciences. They made themselves familiar with the achievements of the Arabic East and began their own scientific activity. The outstanding figure in mathematics and astronomy in the second half of the tenth century was Maslama al-Majriti (d. 1007). An echo of these activities radiated into the (Christian) region of Barcelona. Here scholarly monks in the late tenth century wrote the first Latin treatises based on Arabic materials. As it appears they had at their disposal Arabic texts as well as a specimen of an Andalusian astrolabe and, probably Mozarab, helpers who assisted them in the interpretation of the Arabic materials. Their texts contain portions translated from al-Khwarizmi's treatise on the use of the astrolabe[13] and even two short fragments from Ptolemy's *Planisphaerium*[14] as well as own writings on the subject based on the Arabic materials.

The Catalonian texts, the *Sententie astrolabii* and others, soon spread through many parts of Europe - France, Germany, England - so that gradually the fame of Arabic science was formed. In the twelfth century scholars from various parts of Europe came into Spain with the aim of gathering and translating more of the scientific wealth of the Arabs: Adelard of Bath and Robert of Chester, Hermann of Carinthia, Gerard of Cremona and Salio of Padua, a movement which was also shared by Spanish scholars such as John of Seville, Dominicus Gundisalvi and others.[15]

The conditions under which the "translators" were working in Seville, Toledo and other places in Christian Spain, are not known in all detail: their local affiliation, their knowledge of Arabic - in several cases it is reported that they had the help of native speakers of Arabic, such as Gerard of Cremona who was assisted,

[12] Southern 1981, 21f.; Daniel 1975, 32f.; Metlitzki 1977, 6.
[13] Kunitzsch 1987a.
[14] Kunitzsch 1993.
[15] For a survey of the translations in the field of astronomy and astrology, see Carmody 1956.

in the translation of Ptolemy's *Almagest,* by the Mozarab Galippus (Ghalib);[16] others, like John of Seville, will have been fluent in Arabic - or the possibility of obtaining exemplars of Arabic texts in the area where they were working (that, for example, Gerard of Cremona translated the *Almagest* from Book I-IX after the Arabic version of al-Hajjaj, but the remaining Books X-XIII and the star catalogue, in Books VII-VIII, after the Ishaq-Thabit version, may have come because his Hajjaj manuscript was incomplete or because he obtained a manuscript of the Ishaq-Thabit version in a later stage of his work).[17] The selling of scientific texts to Christians was, for example, forbidden to booksellers by Ibn 'Abdun (d. 1134) in his *risala* (treatise) on *hisba* (market supervision), arguing that then the Christians may claim the originality of the scientific achievements for themselves.[18] Also, on the Arabic side orthodox tendencies were sometimes leading to the condemnation of the pagan sciences and resulted in the destruction of libraries holding such material, such as the destruction of the huge library of caliph al-Hakam II by the *hajib* Abu 'Amir al-Mansur (the *Almanzor* badly known among the Christians, d. 1002). In the thirteenth century the interest in Arabic astronomy reached a last peak under King Alfonso X of Castile (r. 1252-1284) at whose order and with whose own participation again Arabic texts were translated, now into Spanish, and other texts were composed on the basis of Arabic sources, assembled in his monumental compilation, *Libros del saber de astronomia.*[19]

In Sicily the situation was different. The Arab rule there, beginning in 827, lasted for about two hundred and fifty years. After the Christian reconquest, many Arabs remained in the area and left their traces in many fields, administration, architecture, the arts, etc. Speaking of the transmission of Arabic astronomy, we must here mention Michael Scot (d. around 1235) who, beginning his career in Spain, where he translated al-Bitruji's critique of Ptolemy's system, the *De motibus celorum,* in 1217, later moved to Sicily where he became court astrologer of the emperor Frederick II (r. 1212-1250), whose interest in Arabic science and whose contacts with Arab scientists of the time are well-known. Here Michael composed his *Liber introductorius,* a survey of astronomy and astrology in four books based both on classical and on Arabic sources. It seems also to have been in Sicily that the so-called "Sufi latinus corpus" was compiled, comprising an adaptation of Gerard of Cremona's version of Ptolemy's star catalogue to the data of al-Sufi's star catalogue (964 AD) - therefore, not a Latin translation of al-Sufi's book! - and adding illustrations of the 48 constellations as devised by al-Sufi and some other material; the oldest one of the eight manuscripts of the corpus, MS Paris, Arsenal 1036, was perhaps written in Bologna around 1270 and contains a number of hints to Sicily from the late twelfth to the early thirteenth century.[20]

Turning, then, to the Crusaders' lands in Syria and Palestine, it must be said that between 1098, the capture of Antioch, and 1291, the capture of the Crusaders last fortress, Accon, by the Mamluks, these lands contributed remarkably little to the process of transmitting Arabic science to Europe. The only name to be mentioned here is Stephen of Antioch. So far he has been known as the (second) translator, in 1127, of the medical handbook *al-Kitab al-malaki, Regalis dispositio,* of 'Ali ibn 'Abbas al-Majusi (10th century) - a first translation of this work had been made by Constantinus Africanus in the eleventh century, in Salerno *(Liber Pantegni).* Recently arguments have been brought forward that the same Stephen could also be the author of the *Liber Mamonis,* a Latin cosmology describing the Ptolemaic system and using Arabic material, and that the so-called "Dresden *Almagest",* i.e. a translation of the *Almagest* (obviously from Arabic)

[16] According to Daniel of Morley; see Maurach 1979, 244f., cf. also 215.
[17] Kunitzsch 1974a, 97-104.
[18] Cf. Kunitzsch 1992, 73 with n. 5.
[19] Rico y Sinobas 1863-1867; Bossong 1979.
[20] Kunitzsch 1986a, esp. 71-74 and note on 80.

surviving in a single copy, MS Dresden Db. 87, and only containing Books I-IV, might have originated in the same milieu.[21]

At last Byzantium should be mentioned. Here already before the year 1000 AD, Abu Ma'shar's astrological *De revolutionibus nativitatum* was translated into Greek.[22] Traces of Arabic influences are further observed in the eleventh century (MS Paris gr. 2425; Symeon Seth; the anonymous "Methods for Computing....").[23] Calculation with the Hindu-Arabic numerals became known in the middle of the thirteenth century.[24] Near the end of the thirteenth and in the fourteenth centuries the names of Gregorius Chioniades and Georgius Chrysokokkes, respectively, play an important role. The first one visited Tabriz (northern Iran) and learnt Persian himself; he brought back from there to Constantinople astronomical texts, in Persian, and had them translated into Greek.[25] As a commentary to the Persian material, Chrysokokkes wrote an "Introduction to the Persian Syntaxis" (presumably in 1347).[26]

The translations of astronomical and astrological works from Arabic became of fundamental influence in Latin Europe. The texts translated were partly Greek works in Arabic versions, as notably Ptolemy's *Almagest,* and partly original works of Arabic-Islamic astronomers. But it must also be kept in mind that the numerous translations made in Spain were restricted to a choice of Eastern Arabic works available in al-Andalus in the twelfth century, the latest Eastern authors being, as it appears, Ibn al-Haytham (d. around 1041) and 'Ali ibn Ridwan (d. 1061); from al-Andalus, also some authors of the twelfth century such as Jabir ibn Aflah or al-Bitruji were translated. This means that the medieval Western knowledge of Arabic-Islamic astronomy was relatively restricted; the full wealth of Arabic-Islamic astronomy until the twelfth century and beyond remained unknown until, starting from the seventeenth century, early Western orientalists began to study and edit more astronomical material from the Arabic-Islamic world.

In any way, the Latin translations from Arabic exerted an essential influence on the revival of astronomical studies in Latin Europe which led, in the end, to the development of modern astronomy. These translations not only inspired European scholars in the Middle Ages; they were read and discussed into the seventeenth century.[27] This success may, in part, have come due to the invention of printing which made those texts available on a wider range and easier to handle than in the earlier manuscript tradition. Unlike in medicine where in the Renaissance a tendency of "antiarabism" developed,[28] the reputation of Arabic-Islamic astronomy remained unbroken. In the 1530s Peter Apian somehow became acquainted with al-Sufi's Book on the Constellations, reported translated portions from it and even drew a star map including drawings of Old-Arabic asterisms described there.[29] Globe makers of the seventeenth and eighteenth centuries like Willem Janszoon Blaeu, Jacob Aertsz, Colom, Vincenzo Coronelli and George Adams added the constellation names in Arabic, in Arabic script, to the inscriptions on their celestial globes.[30] In 1814, Giuseppe Piazzi introduced nearly a hundred new Arabic star names, beyond those known since the Middle Ages, in the

[21] Burnett 2003. The text called *Liber Mamonis* by Burnett after its title in the manuscript has also been studied by R. Lemay. In his view, however, it is the *Astronomia* written by Hermann of Carinthia; see Lemay 2000.
[22] Pingree 1968.
[23] Hunger 1978, 241; Jones 1987.
[24] Hunger 1978, 245-247.
[25] Pingree 1964; Pingree 1985-1986.
[26] Hunger 1978, 252f.; Pingree 1964; Kunitzsch 1964; Tihon 1987, 1989, 1990.
[27] Knobloch 1996.
[28] Schipperges 1964.
[29] Kunitzsch 1986b, 1987b
[30] Kunitzsch 1997,2001.

second edition of his Palermo star catalogue.[31] The nomenclature of the Moon, created by Francesco Maria Grimaldi and printed in 1651 in Giovanni-Battista Riccioli's *Almagestum novum* contained ten names of famous Arabic-Islamic astronomers in their medieval Latinized forms to which three more were added in 1837 in the *Mappa selenographica* of Wilhelm Beer and Johann Heinrich Madler.[32] In recent times at least ten craters on the far side of the Moon were again named after outstanding Muslim astronomers.

With the growth of the new, heliocentric, Copernican astronomy in Europe, Arabic-Islamic astronomy lost its influence and more and more became an object of historical interest. On the other hand, the new Western astronomy made itself only rarely felt in the Orient and did not lead there to major changes in the traditional science. In single places of contact, elements from the West were copied. So, e.g., star maps in a new Western style, including the newly created constellations in the southern celestial hemisphere, are found on some astrolabes of Muhammad Mahdi al-Yazdi around 1655 in Iran,[33]or in Ibrahim Muteferrika's printed edition of Hajji Khalifa's *Jihannuma,* Istanbul, 1732,[34] or in an Indian cosmological manuscript sometime before 1839.[35] But on the whole, Arabic-Islamic astronomy continued on the geocentric principles on which it had begun in the eighth and ninth centuries.

It so appears that through a thousand and four hundred years the Islamic and the Western worlds, notwithstanding the differences in matters of ideology and social traditions and the intervening opposition of defenders of orthodoxy on both sides, cultivated science in mutual contact. Neither the Muslims hesitated to search and appropriate the *'ulum al-awa'il,* "the sciences of the Ancients",[36] nor spared the Europeans their efforts in search of the *doctrina Arabum,* "the science of the Arabs".[37] In astronomy, technical terms and a wealth of names, for stars and other objects, testify until today to the role played by the Muslims in the development of this science.

In our days science has become universal. Muslim scholars are teaching in many Western universities; Arabs surrounded the Earth on board of spaceships; astronomical research on up-to-date level is conducted in several Arab countries; in 1998 the "Arab Union for Astronomy and Space Sciences" has been founded with its centre in Amman. For the orientalist and historian of Arabic-Islamic science it is a satisfaction to see that the fruitful contact between East and West begun in the Middle Ages is carrying on in the present time.

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[31] Kunitzsch 1959, 230f.
[32] Khan 1953.
[33] Savage-Smith 1992, 65-68.
[34] Lachieze-Rey, Luminet 1998, 90, Fig. 144.
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[36] On the notion of *al-awa'il,* cf. Rosenthal 1960.
[37] Daniel of Morley, around 1270, *apud* Maurach 1979, 212.

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