Guidelines for a Social History of Astronomy

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Abstract: An analysis of the basic cultural, historical and social elements which allowed the re-discovery and transfer of astronomical knowledge from the earlier Middle Ages up to the birth of modern astronomy, is presented in the new book *Storia sociale dell'Astronomia*. The book describes the main factors which played a role in suppressing or re-awakening interest in astronomical observations and events down the centuries. Among such elements we include: the loss of Greek-language-based knowledge as a vector of scientific knowledge; Christian and Islamic conceptions of Astrology; religious practices connected with observations; the birth of universities; the Protestant paradigm and humanism; the evolution of the social figure of the scientist in the West, from monks to aristocrats, and from Renaissance lords to bourgeois entrepreneurs. We focus attention on the social phenomena which caused the development of Astronomy as a science from the Middle Ages to the Copernican revolution, and claim that the ruling class's attitude towards science is not only a matter for historical studies, but has much to do with the modern impoverishment and stagnation of Astronomy.

In this paper, containing a brief summary of our book, *Storia sociale dell'Astronomia* we outline selected historical phases, aspects and individuals in order to stress the importance of the social motives for the evolution of astronomy.[1] We summarise our arguments in this paper and the reader is referred to our book for detailed references. By 'social' we mean a history which is based on cultural, political and, above all, economic requirements: that is, on the interests of the leading social classes as well as on the macro-economic relationships existing within the given society, as in Marxist thought. We also shed some more light on Astronomy beyond Europe – especially in the Islamic world, whose science strongly influenced European science, and in the Chinese Empire, whose astronomical school was highly developed since it played a key

[1] V.F. Polcaro and A. Martocchia, *Storia sociale dell'Astronomia* (Napoli: Edizioni La Città del Sole, 2012).

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role for official China and was, in some epochs, directly controlled by the Emperors who considered it a basic instrument of government.[2]

We start our reflection at the time of the collapse of the Western Roman Empire and the consequent loss of Greek as the language of scholarly scientific discourse. Roman imperial culture was basically bilingual, and both Greek and Latin were known by educated people. Most of the classic scientific literature was written in Greek, as English is today. In Western Europe, when the Roman schools disappeared, Greek was therefore also lost. Thus, astronomical knowledge was also lost, apart from a minor number of texts written in Latin, texts which today we might label 'popular science': in particular, those of Pliny, Macrobius and Martianus Capella.[3] As Christianity became dominant astronomy suffered further; the monastic schools were not interested in research, since their teaching was based on the principle that the whole truth was written in the Bible, and knowledge of natural phenomena was useful only in order to better understand the Holy Books. However, the spread of the Christian religion in the West did play a role in the birth of modern scientific thought. First, being monotheistic, Christian religion wiped away the multitude of godheads and spirits that the ancient world used to associate with natural phenomena, paving the way for 'science' to explain them. Already, in the seventh century Isidore, Bishop of Seville, in his work *Ethymologiarum libri XX* stated that natural as well as human phenomena can be all described independently of any mythical explanation. He also introduced the important distinction – ignored by classical science – between astronomy and astrology; the latter, being in contradiction with the basic Christian principle of 'free will', should be considered as superstition.[4] Further, Christian liturgy demanded the solution of a number of problems connected with time reckoning, such as for computing the date of Easter or the canonical hours, necessary in order to perform liturgical functions. In 725 the British Benedictine Bede (see Figure 1) wrote the *De temporum ratione*, a masterpiece of mathematical astronomy.[5] Monks thus became assiduous and careful

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[2] See, e.g., Z. Xu, D.W. Pankenier and Y. Jiang, *East-Asian Archaoeastronomy* (Amsterdam, The Netherlands: Gordon and Breach Science Publishers, 2000).

[3] Stephen C. McCluskey, *Astronomies and Cultures in Early Medieval Europe* (Cambridge: Cambridge University Press, 1998).

[4] Isidore of Seville, *The Etymologies*, trans. Stephen A. Barney, W.J. Lewis, J.A. Beach and Oliver Berghof (Cambridge: Cambridge University Press, 2007).

[5] Bede, *The Reckoning of Time*, trans. Faith Wallis (Liverpool: Liverpool University Press, 2004).

observers of the sky.[6] A significant role in what could be defined as 'monastic observational astronomy' is due to Irish monks, who transferred the traditional Celtic care for sky observations into the Christian environment, and diffused this knowledge throughout the whole of Western Europe where they established many new monasteries. St. Patrick himself is the reputed author of astronomical books.[7]

Figure 1. *Beda Venerabilis* as depicted by Paschasius Radbertus, late 12th century (Herzog August Bibliothek Wolfenbüttel, 2006)

With the so-called 'Carolingian Renaissance' of the ninth century, the careful observation of the sky became a habit also for the 'Schools of the Episcopates', to which laymen were admitted. In these schools the 'secular' part of the formation included the 'seven liberal arts', one of

[6] See, e.g., R. Newton, *Medieval Chronicles and the Rotation of the Earth* (Baltimore: The Johns Hopkins University Press, 1972); A. Ghignoli and V.F. Polcaro, 'Eleventh Century Astronomical Events as Recorded in Contemporary European Sources', *Mediterranean Archaeology and Archaeometry*, No.6 (2007): pp. 61-66.

[7] A. Gaspani, 'L'astronomia dei primi monaci irlandesi', *L'Astronomia,* No. 199 (1999): pp. 30-39.

which was astronomy. Of course, their teaching was based on the Latin texts cited before, but it was augmented by experimental practice. Furthermore, the larger availability of economical resources allowed the ‘Schools of the Episcopates’ – incubators of the Universities that were established in the following centuries – to introduce the first astronomical instruments used in Europe since the end of the Roman Empire; these were just tubes, used to isolate the star in the viewing field and to measure its altitudinal-azimuthal coordinates. Their use is proof of the increasing interest in the precision of observations.

It was Islam that allowed the rediscovery of Ptolemaic astronomy in Europe (see Figure 2), via the translation into Latin of Ptolemy’s major astronomical work, the *Almagest* – from the Arabic *al-Magisti*. The first Arabic translation from Greek had been done by al-Haggiag ibn Yussuf ibn Matar in the ninth century by order of the Abbasid caliph Harum al-Rashid.

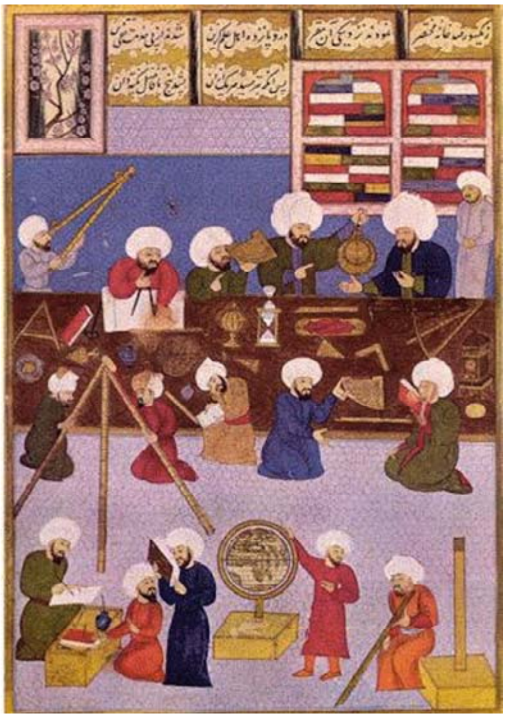

Figure 2. *Arab astronomers* at work, as depicted in a medieval manuscript

The origin of Islamic astronomy is conventionally related to the gift, in 772 AD, of an astronomical book by some Hindi scholars to the Caliph of Bagdad al-Mansur, who immediately ordered to Ibn Ibrahim al-Fazari to translate this book (named in Arabic *Zij al Sindhind*, i.e., *Hindi astronomical tables*) with the help of the same Hindi scholars. The role of Zoroastrian and Sabian cultures and religions also has to be taken into account; Al-Sabi Thabit ibn Qurra al-Harrani (826–901), the translator of Euclid's *Elements* and a renowned astronomer, was a Sabian. The recovery of classical astronomy was immediately followed by the resumption of experimental activities. For instance, the caliph al-Mamun and to his team of astronomers – led by the famous Ahmad al-Farghani (*Alfraganus*) – were responsible for the construction of two astronomical observatories and two extraordinary astronomical achievements: the extremely precise measurement of the obliquity of the ecliptic as 23°33' in 830 CE and that of the meridian degree in 828 CE. Worthy of special mention is the work of Nasir al-Din al-Tusi (1201–1274) and of his team (including even a Chinese astronomer) at the Maragha Observatory in Persia, where a careful process of analysis and revision of the Ptolemaic model was performed. This work, often properly named 'Maragha Revolution', demonstrated the incompatibility of the hypothesis of non-uniform motion and of the introduction of the 'equant' with the Aristotelian principles that were at the basis of the Ptolemaic model. It is very probable that that Copernicus' work actually started from al-Tusi's, given the analogy of the examples used.

There was a notable series of great Islamic astronomers, from the seventh to the fourteenth century.[8] Here, though, we wish to identify the main possible motives for the study of astronomy in the Islamic world:

1. Religious needs: prayers had to be performed at fixed times and in the direction of Mecca (*Qibla*); even the beginning of *Ramadan* was determined by astronomical conditions.[9]
2. The tolerant, syncretic nature of Islamic civilization, and its willingness to assimilate the best of other peoples' knowledge.
3. The need for accurate astrological calculation.
4. The legacy of nomadic Arabic astronomy.

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[8] See, e.g, A. Bausani, *Appunti di astronomia e astrologia arabo-islamiche* (Venezia: Cafoscarina, 1977).

[9] Ruis M. King, 'Finding the Sacred Direction: Medieval Books on the Qibla', in *Cosmology Across Cultures.* Ed. J.A. Rubiño-Martín, J.A. Belmonte, F. Prada and A. Alberdi (ASP Conf. Ser. no.409, 2008), pp. 177-182.

Arabic astronomical knowledge and the related observational techniques reached Europe in the eleventh century; as early as 1050, the Benedictine Hermann of Reichenau wrote a text on the astrolabe.[10] Islamic influence on Western astronomy (and on knowledge as a whole) became of paramount importance during the twelfth century; despite the Crusades, there was not only a clash between Western Europe and Islam, but a fruitful encounter as well. In this context, the role of Emperor Frederick II (1194–1250) as a highly innovative ruler and intellectual is well known, building a bridge between Christian and Islamic civilizations as well as promoting the dawn of 'secular science'.[11]

Figure 3. *Friedrich II with a falcon*, a miniature from his treatise, *De arte venandi cum avibus*, Vatican Library (MS. Palat. Lat. 1071), late 13th century

[10] See, e.g., E. Poulle, 'L'astrolabe médiéval d'après les manuscrits de la Bibliothèque nationale', in *Bibliothèque de l'école des chartes*, Vol. 112, Issue 112 (1954): pp. 81-103.
[11] R. Bressler, *Frederick II: The Wonder of the World* (Chicago: Westholme Publishing, 2010).

Frederick II did not leave us any texts on astronomy but his point of view, fully inspired by Islamic-Ptolemaic astronomy and astrology, is shown through the architectural design of his castles. For sure, Frederick II was the sponsor of the mathematician Leonardo Fibonacci and the astrologer Michael Scot – the latter being partially responsible for the introduction of classical astrology to Europe, via Arabic texts.[12]

Figure 4. *Ptolemy as a cosmographer* in a detail from Waldseemüller's 1507 world map[13]

As a matter of fact, there was no clear difference between astronomers and astrologers until the seventeenth century. After astrology was reintroduced in Europe in the twelfth century, astronomy became a lucrative and respected profession; the number of astronomers, and thus the number of astronomical studies and results, started to increase. From the fifteenth century onwards, with the great geographical 'discoveries'

[12] L. Sigler, *Fibonacci's Liber Abaci* (New York: Springler-Verlag, 2002).

[13] In *Die älteste Karte mit dem Namen Amerika aus dem Jahre 1507 und die Carta Marina aus dem Jahre 1516 des M. Waldseemüller (Ilacomilus)*, ed. Jos. Fischer and Fr. R. v. Wieser (Innsbruck: Wagner, 1903).

and colonial conquests, another major reason for the growth of astronomy was the need for reliable, long-range navigation. This is why, in that epoch, astronomers were often referred to as *cosmographers*: that is, those who were able to provide advanced geographical maps of the universe (*cosmos*) – actually, the known Earth.

Roger Bacon, (ca. 1214–1294), was a Franciscan Friar, but studied at Paris University and became an independent scholar. His many cultural interests included astronomy; his *Opus Major* also deals with the positions of the celestial bodies, including the clear statement of the Earth's sphericity and some criticism of the Julian calendar. Bacon was condemned by his Order in 1278, most likely due to his involvement in astrology and alchemy. More generally, his 'fault' had been to be a critic of the 'authority principle' and to believe experience to be the means to obtain knowledge of Nature, an attitude which represented a clear step towards Renaissance Humanism.

Two crucial roles in changing the physical paradigm of the Universe – from finite and Earth-centred, to infinite and isotropic – were played by Thomas Bradwardine (fourteenth century) and Nicholas of Cusa (fifteenth century), who at the same time enjoyed and contributed to the new cultural atmosphere. The development of scientific procedures for cartography is an example of the whole epistemological process which characterized Renaissance Humanism; just as so-called *cosmographers* started communicating with sailors, all *philosophers* started to appreciate empirical experience acquired by technicians, thus becoming *scientists* in the modern sense. In particular, astronomers soon started to work together with artisans: joiners, mechanics, all sorts of craftsmen. The main case is the one of Tycho Brahe (1546–1601) (see Figure 5) with his many collaborators assisting him in the Uraniborg and Stjernberg observatories.[14] Tycho, a powerful lord, is the model of a Renaissance intellectual: an individual who was *master* in the now *fully human* enterprise of understanding the universe.

Empirical experience was thus getting unprecedented appreciation in Western culture. A key role in this cultural process was played by the Protestant movement, for self-evident reasons. Tycho was a Protestant; moreover, while Copernicus (1473-1543) was himself Catholic, the main backers, popularisers and refiners of his theory were all Protestants, especially Lutherans: Rheticus and Rheinold (both based

[14] V. Thoren, *The Lord of Uraniborg: A Biography of Tycho Brahe* (Cambridge: Cambridge University Press, 1990).

in Wittemberg, Luther's home town), Osiander, Maestlin, and Kepler (1571–1630).

Figure 5. *Tycho Brahe at work* in an often-reproduced view (slightly different versions available in several 16th-century prints)

The birth of modern astronomy in the West can be virtually dated back to 1609, the year of the publication of the most important works by Kepler and Galileo Galilei (1564–1642). It is also usually claimed that Galileo was the founder of the *scientific method* itself, although an exact definition of the latter can be the subject for lengthy and complex discussions. As a matter of fact, while Kepler was still strongly influenced by metaphysical and symbolical schemes (his *Armonices Mundi* describes the Universe as divine Music), Galileo was not (apart from his metaphysical conception of mathematics).

Even more importantly, Galileo is also represented as the prototype of a modern scientist from the social and professional points of view. He was born in a middle-class family, his father Vincenzo working as a wool trader to live while involved in musical theory and *production*, as an artisan and composer. Interestingly, Vincenzo was very much interested in the *physical* mechanisms of sound production and their mathematical description. His empirical and critical mentality had a strong influence on the young Galileo. So the latter learnt to appreciate advanced instrument- and spectacle-making; the telescope came from Dutch artisans and was not his invention, but he knew how to profit from it (see Figure 6). In fact, Galileo's figure is that of a modern bourgeois scientist; his attempt to 'sell' the telescope to the Venetian nobility and his famous conflict with the Roman clergy tell us a lot about the advance of a new social class.

Figure 6. *Galileo Galilei showing his telescope to the Signoria of Venice*, a printed reproduction of Guglielmo De Sanctis' painting (Rome, Museum of Rome)

Even if our *Storia sociale dell'Astronomia* draws attention to the social phenomena which caused the development of Astronomy as a science from the Middle Ages to the Copernican revolution, we believe that this special way to look at the history of science has a lot to teach us about the present. At the end of this journey through time, the figure of Galileo – the prototype of a modern scientist not only because of his theories and method, but also from the social and professional points of view – is especially significant.

Like some modern scientists, Galileo learnt to be the promoter and populariser of his own scientific work. Therefore he preferred to write his *Dialoghi* in modern Italian ('*volgare*') instead of using Latin; he aimed at the broader public of lower-class readers. In that epoch, in fact, several scientists arose from the lower classes: mere craftsmen, people who could not even read Latin. The difficulties of the 'struggle for science' have not disappeared at all. In fact, chances for a career as well as budget conditions do still depend on the more general social, historical, and political context. And the attitude and interests of the ruling classes should be taken into account when we attempt to explain why the development and transfer of knowledge are sometimes inhibited or stopped altogether.

It is, of course, a social problem that brilliant individuals and scientists must sometimes live with an uncertain salary or none at all, even though they contribute to the development of astronomical knowledge or to its transfer to future generations. Even if we focus attention only on the situation in Italy and the UK, we find clear indications of this crisis, which is could be seen as part of a more general cultural crisis in Western societies.[15] In Italy, we experience huge difficulties with funding and employment policies in astronomy. Recently, there was an attempt to shut down the National Institute for Astrophysics; at present, smaller observatories have been virtually abandoned by the Institute itself. The latest demonstration of the Italian government's attitude towards science is in a sentence that was reportedly said by the Italian Prime Minister very recently. He declared: 'Why do we need to pay scientists when we are already able to make the best shoes in the world?' This was his reaction to complaints by Italian universities, which say they will be unable to pay staff wages in 2011. However, different governments have not made the situation better as far as funding for science and education is concerned.[16]

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15 'Adopt an Italian Astronomer' at http://adoptitaastronom.altervista.org/index.html [accessed 20 October 2010]; 'STFC Funding Crisis: Astronomy' at http://pacrowther.staff.shef.ac.uk/stfc.html [accessed 20 October 2010].

16 'Support Italian Research and Education' at http://no-brain-no-gain.net [accessed 20 October 2010].