Studies in Medieval Astronomy and Optics by José Luis Mancha

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Over the last 15 years, J. L. Mancha has published a series of studies, mostly connected in one way or another with the work of Levi ben Gerson, in which he brings to bear his considerable skills in Romance philology and mathematics. Eleven of these have been collected in the volume under review, to which Mancha has added a preface and indices. Mancha was led to study Levi by way of his dissertation in which he wrote on Henry of Hesse's *De reprobatione eccentricorum et epiciclorum*. Hesse's criticisms of eccentrics and epicycles resonate in the work of Regiomontanus and Copernicus. The search for Hesse's own sources led Mancha to Levi, who, as noted, has become the chief focus of his work. Only one of the essays reprinted here, 'Ibn al-Haytham's Homocentric Epicycles in Latin Astronomical Texts of the XIVth and XVth Centuries', (to which I shall return below) is related to Hesse. By contrast, nearly all of the others, and certainly the longest and most important, are related directly or indirectly to Levi.

Research into Levi, in turn, led Mancha to other projects. The first two items in the volume are studies of Latin texts on pinhole images. Levi employed the pinhole camera for his measurement of the solar eccentricity; a study of the Latin version of the relevant chapter from Levi's astronomy is appended to the second of the two essays on optics, 'Pinhole Images in William of Saint-Cloud's *Almanach*'. The last study in this volume, 'Al-Biṭrūjī's Theory of the Motion of the Fixed Stars', confirms the suggestion of E. S. Kennedy, against the view of B. R. Goldstein, that al-Biṭrūjī did employ a pair of homocentric spheres (dubbed by Mancha a 'Eudoxan couple') in his reformed astronomy. The clue to this new interpretation, as Mancha tells us in his third footnote, was the discovery that Levi had used homocentric

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spheres in dealing with the hippopede, a topic which Mancha investigates in full in the seventh item in the volume, 'Right Ascensions and Hippopedes: Homocentric Models in Levi ben Gerson's *Astronomy* I. First Anomaly'.

In the following I shall report upon some selected essays from this collection, in particular, those to which I wish to draw attention or to which I feel that I may have something to add. I shall, however, jump directly to my conclusion now, and state that this a welcome addition to the Variorum series and a most useful work for historians of medieval science.

Let me begin with a remark on the hippopede. Mancha observes that the chief source for the technical features of the model is Simplicius' commentary to Aristotle's *De caelo*. Although that text is not known to have been translated into Arabic, somehow the procedures became known, and even became 'standard'. In this connection, I should draw attention to the very interesting Hebrew text, *Meyashsher Aqov*, which is likely to have been written by Abner of Burgos (early 14th century), and which is a repository of some rich Hellenistic mathematics not known from other medieval sources as well as other materials whose transmission history is unclear. Abner was clearly drawing upon texts that may well have been at the disposal of al-Biṭrūjī and others.[1]

'Heuristic Reasoning: Approximation Procedures in Levi ben Gerson's *Astronomy*', is the most thorough study I have seen of iterative methods in pre-modern science. An iteration is a process for solving algebraic (or transcendental) equations in which one first makes an educated guess as to the solution, then 'plugs' this solution into an algorithm which will yield a better approximation. This second solution is then 'plugged' into the same algorithm, yielding an even better solution. After a number of successive iterations, the differences between the results become insignificant, and one can be satisfied with the result.

Iterative procedures were employed not only by Ptolemy (as Mancha notes) but elsewhere in Hellenistic mathematics and in medieval Hebrew mathematics as well.[2] However, as Mancha points out,

[1] I report much of this in Langermann 1996.
[2] See Hogendijk 1994, Langermann 1994.

astronomers and mathematicians did not always explain exactly what they were doing, nor did they attempt to justify the method on mathematical or logical grounds. Levi, however, did both at the beginning of chapter 49 of the Latin version of his *Astronomy*. After translating and analyzing the relevant text, Mancha goes on to display six examples of its application in a variety of astronomical problems.

By far the longest study (nearly 100 pages) is 'The Provençal Version of Levi ben Gerson's Tables for Eclipses'. The text, whose discovery is an important achievement in itself on Mancha's part, sheds new and stronger light on Levi's relationships with Christian scholars. In particular, Mancha demonstrates that the Provençal text, which is earlier than the corresponding Hebrew version and contains materials not found there, is due to Levi himself, who may have dictated it to a Christian scholar, very likely Petrus of Alexandria, who is known to have been associated with Levi in various capacities. Having now the opportunity to study closely Levi's work in all of the three languages in which they circulated (Hebrew, Provençal, and Latin), Mancha is led to the important conclusion that one ought not to speak of 'originals' and 'translations'. Instead, each version, whatever the language, presents Levi's original research at whatever stage the text was issued. Moreover, the Provençal and Latin versions are not mere translations, but rather form part of a program undertaken in collaboration with Levi himself for making available the results of his astronomical research to the aforementioned Christian circle.

'Levi ben Gerson's Astronomical Work: Chronology and Christian Context', deals as well with Levi's relations with Christians. It is, however, a departure from Mancha's usual work in that neither mathematical astronomy nor Romance philology play a major role here. It is, nevertheless, one of the most interesting and revealing contributions to Levi's biography that I have seen. Making use in particular of the many dated observations in Levi's writings, Mancha points to peaks in astronomical research that correspond to requests from Christians, as well as to low points that came about when Levi was stymied. Levi's writings in other fields, especially biblical exegesis, fit in nicely to those years when astronomical activity is not attested.

'Ibn al-Haytham's Homocentric Epicycles in Latin Astronomical Texts of the XIVth and XVth Centuries' tries to draw a connection between a physical model proposed by Ibn al-Haytham to account

for the complex motions in latitude of the planets, and some models that are found in Latin texts. Ptolemaic astronomy analyzed motion in latitude as the product of an oscillatory motion on the part of one, or, in the case of the inferior planets, two diameters of the epicycle. Yet how is one to explain this physically in accordance with the principle that only one motion can be attributed any single body in the heavens? Ibn al-Haytham (965–*ca* 1040) devised a system of concentric spheres rotating on different poles to account for it. Mancha has found in works by Henry of Hesse, a certain magister Julman, and Albert of Brudzewo (author of a gloss to Peurbach's *Theorica*), 'physical arrangements of two concentric spheres enclosing the epicycle (or the eccentric) identical to that of Ibn al-Haytham. . . although without parameters'.

So far so good. The problem—and Mancha is certainly aware of it (see his first note)—is that the particular monograph in question, *Treatise on the Movement of Iltifāf*, is not extant even in Arabic; and there is no reason at all to suppose that it, or the reply of Ibn al-Haytham to a critic of his solution, which does survive, would have been available to readers in the West. Ibn al-Haytham's *On the Configuration of the World*, by contrast, was widely read and translated more than once into Latin. In that book, however, Ibn al-Haytham does not offer a solution to the problem at hand, though the oscillations are mentioned, and the Latin terms (*reflectio, inclinatio*) are the same as those that appear in the texts studied in this article. Mancha observes that the authors whom he studies did not themselves design the system, since they speak of it as the theory of others. However, the models are not complex, and involve little more than the assumption of spheres that will be responsible for the execution of the motions that are described in *On the Configuration* and other writings.

I have some criticisms concerning Mancha's translations and transcriptions. Mancha's command of English is excellent, and his expositions and translations read well. However, he has a tendency to translate some terms much too literally. For example, in the first study, 'Egidius of Baisiu's Theory of Pinhole Images', he consistently renders '*pyramis*' by 'pyramid', instead of 'cone', the correct and

precise translation.[3] Mancha chooses 'diaphaneity' for '*diaphanitas*', instead of the perfectly good 'transparency' [passage 13]. He uses 'experience' too often, inconsistently, and not always correctly. At the beginning of passage 19, '*Etiam est contra sensum*' is rendered 'It is also contradicts (!) experience'; and at the beginning of passage 20, '*Ad quod experimentum quidam falso nituntur respondere*' is given in English as 'This is an experience against which some try in vain to argue'. '*Sensum*' should be rendered 'senses', or, if one insists, 'sense experience'; and '*experimentum*' in this context really means 'observation', or, if that seems inappropriate, 'empirical datum'. (The same applies to Mancha's use of 'experience' on page 15 of the fifth item in the collection).

Passage 18 in the first study presents a more difficult challenge. The Latin has '*virtus curvaretus et fortificaretur*', which Mancha translates, 'their virtuality would curve and increase in strength'. 'Virtuality' is of course out of place here; '*virtus*' must mean here 'power, strength', and so one would accordingly translate '*fortificaretur*' by something like 'would intensify'. I admit, though, that the full intent of the passage is beyond me. Finally, a word on transcriptions from the Greek. In the eighth study, Mancha consistently writes '*egklisis*'. This may be a precise letter for letter transcription; but gamma before kappa is a palatal nasal stop, and so the correct and standard transcription is '*enclisis*'.

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[3] See, e.g., Kheirandeish 1999, 2.154 for the employment of this technical term in the Latin version of Euclid's *Optics*.

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