ʿALĪ QUSHJĪ AND REGIOMONTANUS: ECCENTRIC TRANSFORMATIONS AND COPERNICAN REVOLUTIONS

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In 1973, Noel Swerdlow presented a new and significant reconstruction of how Copernicus arrived at the heliocentric theory.[1] This reconstruction was based upon several bits of newly-interpreted information, most importantly a set of notes in Copernicus's hand contained in an Uppsala University manuscript. These notes provided compelling evidence that Copernicus had transformed Ptolemy's epicyclic models of the planets into eccentric models as a first step in developing a Sun-centred astronomy.[2] But this transformation depended upon a general proposition that one could indeed convert all the epicycle models into eccentric ones. Curiously, Ptolemy denied this, claiming in Book XII of the *Almagest* that this was possible only for the outer planets (Mars, Jupiter, and Saturn) but not the inner ones (Mercury and Venus). From a modern perspective this seems odd, and it is not entirely clear why Ptolemy could not see that the epicycles of the inner planets, with a proper consideration of speeds, could also be converted into eccentrics. Indeed, Ptolemy's modern translator Gerald Toomer says: "I do not understand why Ptolemy does not recognize this."[3]

Be that as it may, it would seem that no one else recognized this until the fifteenth century. Swerdlow found what he believed to be the source for the propositions Copernicus needed to begin his conversions, namely Book XII, Chapters 1 and 2 of Regiomontanus's *Epitome of the Almagest*.[4] In Chapter 2, Regiomontanus gives a brief sketch and proof of the crucial theory for the inner planets, which would allow Copernicus to convert all the planets from epicyclic to eccentric models. Though Copernicus is sparing in his references and nowhere cites Regiomontanus for these propositions, his use of the *Epitome* is well-documented, and there would seem to have been no other European source that he could have depended upon.[5]

Whatever subsequent use was made of them, Regiomontanus's own motivation for including these propositions at the beginning of Book XII has remained unclear. Swerdlow himself signalled this when he stated: "For some reason the eccentric model must have caught Regiomontanus's attention…."[6] And Michael H. Shank has recently remarked that "We do not yet know specifically what, apart from his compulsive thoroughness, motivated Regiomontanus to explore the eccentric models of the second anomaly".[7] What is especially odd about Regiomontanus's interest is that it is apparently so unprecedented. Neither in Europe nor in the Islamic world does this eccentric alternative alluded to by Ptolemy seem to have generated much interest. And the motivation to extend this alternative to the lower planets, after being rejected by the great authority himself, is even more puzzling. Finally, there is the odd way in which Regiomontanus presents the two propositions. He himself gives no motivation — he just presents them. There is no mention of Ptolemy, no