ΔT AND TIDAL ACCELERATION VALUES FROM THREE EUROPEAN MEDIEVAL ECLIPSES

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ABSTRACT. There are many possible reasons for the fact that the rate of rotation of the Earth is slowly decreasing in time, being the most important the tidal friction. Since Universal Time (UT) is a time scale based on the rotation of the Earth and ΔT is defined as the difference between the uniform time-scale (Dynamical Time), and the Universal Time, clearly that ΔT will vary with time. The problem is that this variation is not uniform, existing irregular fluctuations. In addition, it is not possible to predict exact values for ΔT, being the only possibility its deduction a posteriori from observations. ΔT is strongly related with occultations and eclipses, because it is used for the calculation of exact times of the event, and for determining the position of the central line or the zone of visibility. In this sense, a value ΔT =3600s is roughly equivalent to a shift of 15° in longitude. Past values of ΔT can be deduced from historical astronomical observations such as ancient eclipses which have been widely studied by F.R. Stephenson [3] and [4] who has even obtained an approximation fitted with cubic splines for ΔT from -500 to +1950. This approximation is nowadays widely used in astronomical calculations. The derived relative error from ΔT obtained from ancient eclipsed is quite large, mainly because of the large width of the totality zone and the inaccuracy in the definition of the observational place. A possibility to partially solve these former problems is the analysis of total eclipse records from multiple sites, which could provide a narrow parameter range. In addition, The conjunct analysis of these astronomical phenomena is useful for determining a range of ΔT in function of the tidal acceleration of the Moon. Further discussion about these eclipses in under review.

1. THE ECLIPSES OF 3^{RD} JUNE 1239, 6^{TH} OCTOBER 1241 AND 17^{TH} SEPTEMBER 1354

The eclipse to 3th June 1239 is one of the most recorded in the history [2]. As an example, we shall only make reference to one record from [1] (chap. 305) of King Jaume I which makes reference to the eclipse as seen from the city of Montpellier: "(...) I went to Montpellier. One Friday, between midday and nones, there was the greatest eclipse seen in the memory of men now living, for the moon covered the whole of the sun, and one could see seven stars in the sky". The AD1241 eclipse was also recorded twice in the city of Soria: in the Concatedral of San Pedro is written "OBSCVRATVS E(st) SOL(s)T(i)CIO IV" and not further, in the San Nicols church (in ruins) a fragment remains with the following inscription: CVRAT(us) EST SOL(sticio) ER(a) MCCLX(xvii). The word "Era" refers to the Spanish era (38 years must be subtracted to transform it into the Julian date). All the other observation records for this eclipse are taken from [4]. Finally, the AD1354 eclipse was hybrid. Stephenson records only one account in the city of Perugia, where the eclipse was partial, although very large. We will use data obtained from Sos del Rey Catolico [2] to improve the wide range of ΔT obtained using Perugias observation. The former reference shows a pair of inscriptions sited in the arc of middle point of the arcade overlooking the Council place. In one of them it reads: Anno domini MCCC: L: IIII XVII die septembris: hora prima: Obscura uit sol. The translation will be: "In the first hour of the 17 September in the year of God 1354 the sun got dark."

2. DETERMINATION OF ΔT AND THE TIDAL ACCELERATION

In the study of the variation of the Earth rotation using untimed observations of total eclipses, the precision of the ΔT obtained values depends mainly on the width of the totality band and on the precise definition of the observational place (See Fig. 1, for the AD1239 eclipse), it follows that the analysis of the eclipse observed from multiple sites provides more precise measures. There is the possibility of including also the conjunct determination of ΔT and the variation of the tidal acceleration of the Lunar Motion following [5]. To this aim, we have chosen three eclipses observed in Europe in the XIIIth and XIVth centuries, and we have obtained the ranges of ΔT for different values of the tidal acceleration (see Fig. 2). The inclusion of other almost contemporary eclipses could provide a narrower range of ΔT for each value of the tidal acceleration and help to identify redundant or inconsistent observations.

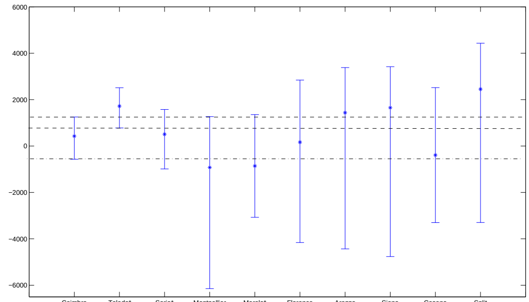

Figure 1: Values for ΔT at the observational sites. The mean value is 618 s. The dashed-lined interval represents the ΔT considering all sites, the dotted-solid line is the former value without Toledo.

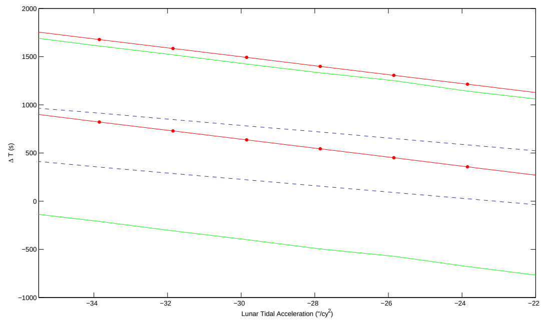

Figure 2: Total eclipse regions in the $(\Delta T, \Delta\dot{n})$-plane. We represent the data from the eclipse in AD1239 (solid line), AD1241 (solid-pointed line) and AD1354 (dashed line). If $\Delta\dot{n} = 0$ the range is 451 s$<$ ΔT $<$650 s. For the two contemporary eclipses (AD1239 and AD1241) we obtain 451 s$<$ ΔT $<$1251 s.

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