HISTORICAL NOTES

JULIAN DAYS IN ASTRONOMY

Epochs such as that of *Kaliyugādi*, *Varahamihira*, Brahmagupta, *Karaṇ akutūhala* etc. have been expressed in terms of the current Julian days as used in astronomy with sufficient explanation. Certain errors in the published data of JDN is also pointed out to avoid confusion.

The system of Julian day numbers (JDN) is a continuous count of days elapsed since the beginning of the Julian period as defined by the sixteenth-century chronologist J. J. Scalinger. Although Scalinger's original idea was to introduce a count of years, nineteenth-century astronomers adapted this system to create a count of days .....Julian day '0' commenced at Greenwich noon on − 4712 January 1, Julian proleptic calendar. The Julian day number, expressed as an integer, denotes the number of complete days elapsed since the initial epoch.[1]

JD count begins at Greenwich mean noon or 12:00:00 GMT of 1 January −4712. Bag in his earlier publications[2] has based all his arguments by defining the Julian epoch as 00:00 GMT on Monday night thereby adding 0.5 days to the Julian count of days to justify his arguments.

In astronomical computations it is necessary that the Julian date has to be mentioned in decimal with the specification of the time scale employed viz., Dynamical Time or Universal Time. For example:

1. On the date of Kali Epoch mentioned by the author, 18 February 3102 BC 06:00 Ujjain Mean time, the Dinamical time will differ by 1 hour 26 minutes 07 seconds. JD (UT) = 588465.53958330 or JD (TDT) =

588465.59939120 or JD (ZT) = 588465.75 and JD number indicating elapsed days should have been 588465.

2. For 22 March 505 AD (Tuesday) 06:00 Ujjain MT, TDT will differ by 1 hour 16 minutes 41 seconds. JD(ZT) = 1905589.75 = 1905589.5333333958333 or JD (TDT) = 1905589.59283796 and the JD number = 1905589. Kalidina will be = 13171214.

3. 23 March 665 AD (Sunday) 06:00 Ujjain MT, TDT will differ by 0 hour 56 minutes 40 seconds JD (ZT) = 1964030.75 or JD (UT) = 1964030.53958333 or JD (TDT) = 1964030.57893403 and the JD number = 1964030. Kalidina will be = 1375565.

Above data was given with reference to the *audayika* reckoning and midnight reckoning would have introduced a decrement of 0.25 days.

K_0 epoch in *audayika* = 588465.5395833 in UT.

K_0 epoch in *ardharātrika* = 588465.2895833 in UT. Both these needs correction of DT= TT-UT to yield the correct planetary positions. JD as given can not give any true assessment about the epochs if used for planetary computations.

K_0 epoch in *audayika* = JD (TDT) : 588465.59939120.

K_0 epoch in *ardharātrika* = JD (TDT) : 588465.34939117.

Kali, Varāhamihira, Brahmagupta and Karaṇakutūhala and Grahalāghava epochs:

(1) *Kali epoch and JD Number* : Bag takes JD Number for 18 February, –3101 AD 06:00 UMT as 588466 where as it is actually 588465.539583 (for 00:57 UT = 06:00 UMT). Error in Bag's number can be traced to the additional +0.5 days arising from his erroneous Julian epoch.

It may be noted that 588465.5 mod. 7 = 3.5 or Thursday midnight and 588466 gives Friday noon and the derivation of weekdays from JDN and Kali reckoning cannot be reconciled due to the half-day difference in counting. 12:00 GMT means 1703 UMT and as such the difference

between JDN and Kali Ahargaṇa is 0.46042 days with the *audayika* reckoning and 0.71042 with the *ardharā trika* reckoning.

(2)   *Varāhamihira Epoch: Tuesday, Caitra 1,427* Śaka (22 March 505 AD)

As *Varāhamihira* had used the year length of 365.25875 days, we have to consider the epoch by the *ardharātrika* system. 21 March 505 AD, 18:57 UT corresponds to 22 March 00:00 UMT or JD of 1905589.28958333 having true sun and moon at 02.42 and 04.47 respectively.[3]

JD Number 1905589 refers to the weekday of 12:00 GMT on 21ˢᵗ March 505 AD, Monday to 24:00 GMT of 21.03.505 AD and this Monday is over at 1905589.5 as per Julian reckoning (1905589.5 mod. 7=0.5 or Monday midnight). The JDN = 1905590 begins at Tuesday Noon and has nothing to do with the 06:00 UMT of Tuesday. *Tithi* elapsed at 1905589.28958333 and 1905590 shall obviously be different leading to wrong conclusions in modern studies on Indian Astronomy.

Epoch of *Varā hamihira* was the expiry of 3606 Kali years = 1317123.0525 Kalidina. The Kalidina of the epoch can be taken as 1317123 if Dhruva is defined for the surplus of 0.0525 days. Precisely, JD (UT) = 588465.2895833 (*ardharā trika*) + 1317123.0525 = 1905588.342 UT. In TDT, the JD count is 1905588.40181 for use in astronomical computations. 3606 Kali years as such lead us only to 20ᵗʰ March 505 AD, 20:12:28.8 UT of Sunday night. True Sun and Moon were 01-47 and 352.25 (new moon) respectively.

Bag has given no reference for placing the *Varā hamihira* epoch as of *Kalidina* = 1317124 corresponding toTuesday.

SB Dikshit in his work.[4] has shown that the epoch of *Sūryasiddhānta* available in *Pañcasiddhāntikā* is Sunday, 14ᵗʰ tithi of the dark half of Caitra. Year length is 365.25875 days. New moon corresponded to Monday, 21ˢᵗ March 14:52 UT [1905589.11965927 JD (UT) and 1905589.17291390 JD (TT)]. 3606 x365.25875 leads to 1317123.0525 and in the *ardharātrika* system Sunday is over at midnight and the epoch is 01:16 past mindnight or 48 gh 09 vigh after mean sunrise of Ujjain.

Mean position of Sun as per the *Sūryasiddhānta* of *Pañcasiddhāntikā* is 359⁰ 27′ 18′′ and moon 350⁰ 11′ 16′′ for Ujjain mean noon of Sunday which is 33 gh 10 vigh before the epoch.

For Tuesday mean sunrise of Ujjain (22.03.505, 06:00 UMT), JD (UT) = 1905589.5395833 and JD (TDT) = 1905589.59939120. True sun and moon were 02-57 and 08-12, Caitra śukla (1). For the JD data of Bag, 588466 + 1317124 = 1905590, the date is Tuesday 12:00 GMT or 1703 Ujjain Mean Time – a wrong conclusion for the epoch of Varāhamihira. Siddhantic epochs based on Kalidina are mostly defined by the mean position of Sun and expiry of the Kali year and not by the Caitra śukla (1).

(3)   *Brahmagupta epoch : Sunday Caitra 1, 587* Śaka (23 March 665 AD).

JDN (Bag) = 1964031 : This refers to the day beginning at 12:00 GMT of Sunday and not the 00:00 GMT of Sunday or mean sunrise at Ujjain. As shown earlier it can be demonstrated that the JD (UT) for 23 March 665 AD, 06:00 UMT or 00:57 UT is 1964030.53958 for which the true sun and moon will be 05-08 and 10-09 corresponding to Caitra śukla (1). Kalidina for 3766 years of 365.25875 days of *Khaṇḍakhādyaka* is 1375564.453 days which on midnight reckoning yields a JD (UT) of 1964029.7420, JD (TDT) = 1964029.781351 (True sun 04-21 and moon 00:14: new moon of amanta Caitra) i.e. 22 March Saturday 05:48 UT or 10:51 Ujjain Mean Time. Dikshit has observed that *Khaṇḍakhādyaka* follows the *Sūryasiddhānta* of *Pañcasiddhāntikā* according to which the solar ingress was at 12gh 09 vigh on Saturday.[5] This observation of Dikshit agrees well with the above data.

(4)   *Epoch of Karaṇakutūhala* :
Bag placed the *Karaṇakutūhala* epoch at Thursday, Caitra-śukla (1) mean sunrise Śaka1105 (24 February 1183 AD), Kalilnda[6] = 1564737.

On the other hand Dikshit has described the epoch as coinciding with new moon. JD (UT) for 06:00 Ujjain Mean Time is 2153202.53958333 and the Kalidina is 2153202.5395833-588465.5395833=1564737. If Bag's formula is adopted, JD will be 1564737+588466 = 2153203 which will be 12:00 GMT of Thursday, 24th February 1183 AD.

(5)   *Epoch of Grahalāghava: Caitra S(1),* 19 March 1520 AD, *Kalidina = 1687850*

As shown by Dikshit, epochal positions of *Grahala̅ghava* correspond to the sunrise of Monday, the new moon day having mean sun at $349^0\,41'$ and moon at $349^0\,06'$. For Kalidina of 1687850, JD (UT) in the *audayika* system is 2276315.5395 which is Monday 19 March 00:57 UT and 06:00 Ujjain Mean Time. New moon was for JD (UT) = 2276315.70925 with the luminaries at $08^0\,07'$. *Ayanāṃśa*[7] as per *Grahalāghava* was $16^0\,38'$. Therefore the sideral position of true sun would have been $351^0\,29'$. Subtracting the equation of center $1^0\,40'$, we get mean sun for the new moon as $351^0\,51'$. The JDN will be 1687850+588466 = 2276316 will infact indicate the Ujjain evening of Monday rather sunrise at Ujjain.

Further, a few other JDN which needs correction are given below:

01.01.Year	Bag's JDN	Correct JDN
1700 (G)	2341972	2341973
1800 (G)	2378496	2378497
1900 (G)	2415020	2415021
2000 (G)[8]	2451545	2451545
2100 (G)	2488069	2488070
2200 (G)	2524593	2524594

This I hope will present a correct perspectives to the readers.

References

1. Explantory Supplement to the Astronomical Almanac, edited by P. Kenneth Seidelmann, p. 600.
2. A. K. Bag 'Luni-Solar Calendar, Kali Ahargana and Julian Days', *IJHS* 38.1(2003) 17-37; see also 'A Note on the Ahargana and the Week Days as per modern *Sūryasiddhānta*', *IJHS*, 38.1 (2003) 39-42.
3. In the *audayika* reckoning 22 March 505 AD, 00:57 UT or 06:00 UMT corresponds to JD of 1905589.53958 having true sun and moon at 02-56-44 and 08-06-43 respectively.
4. S. B. Dikshit, *Bharatiya Jyotish Sastra*, Part 2, p.23.
5. S. B. Dikshit, *Bharatiya Jyotish Sastra*, Part 2, p. 88.
6. *IJHS*, 38.1(2003) 27
7. *Grahalāghava* of Gaṇesa, edited by R. C. Pandey, Chowkhamba Sanskrit Series 1994, p.49
8. Here Dr. Bag is correct as JD for 01.01.2000 is 2451545 at 12:00 GMT

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