The need and opportunity to develop more accurate 4000-year ephemerides, using lunar and spacecraft ranging and ancient eclipse and planetary data*

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The initial conditions of the JPL DE102, BDL VSOP and ELP2000 ephemerides were based on observations up tp 1977. Much more tracking data have been collected since. Lunar laser ranging has also given an accurate $\dot{n}_{moon}$ of $-25.9 \pm 0.5''/cen^2$ (EOS **73**, No43, 126). The lack of ΔT values before 700 BC had left the early timescale of the ephemerides unconstrained (Morrison, *Observ.***112**, *289*). We summarize our effort to solve this problem here.

Since $\Delta T = ct^2$ (t is cen before 1800) the oldest data have the most weight. The *Bamboo Annals*, entombed in 299 BC and unearthed in AD 281, states that "in the 1st year of King Yi of the W Zhou dynasty the day dawned twice at Zheng $(34.5°N, 109.8°E)$." *Kayuan zhanjing* [AD 724] adds that "in the 2nd (actually 12th) year of Sheng Ping reign period of King Shang (actually King Xi) the day began twice at Zheng." Matching these records with the 4/21/899 BC and 4/4AD 368 sunrise eclipses gives ΔT values of5.8 ± 0.15 and 1.7 ± 0.1 hr [*Vistas Astron.***31**, 833; *EOS* **73**, No 43,62]. Analysis of Shang dynasty oracle bone eclipse records gives ΔT values of 7.3-7.2 hrfor 14-12 th cen BC [*Bull. Am. Astron. Soc.* **21**, 753; *EOS* **71**, No43, 1269]. Our best-fit equation is $\Delta T = (30 \pm 2.5)t^2$.

From this we get an $\dot{\omega}/\omega$ of $-(19 \pm 1.6).10^{-11}/yr$. Substracting a tidal $\dot{\omega}/\omega$ of $-(27.8).10^{-11}/yr$ [Lambeck, 1980] gives a nontidal $\dot{\omega}/\omega$ of $(9 \pm 1.6).10^{-11}/yr$ [J_2 of $-(4.5 \pm 0.8).10^{-11}/yr$]. The historical and present J_2 from satellite laser ranging, $-3.10^{-11}/yr$ are consistent with postglacial rebound from an upper mantle of viscosity $10^{21}Pas$, and lower mantle of $(2-4).10^{21}Pas$, deformed by Pleistocene ice sheet loading. The bounceback to its less oblate interglacial

shape makes the Earth spin faster, overcomming a third of tidal bracking. The net effect has been lengthening the day by $1.64 \pm 0.14 msec/cen$. Successful matching of Chinese records with the 9/24/1912 BC sunset eclipse, and late 3rd millenium BC lunar eclipses wuth Babylonian cuneiform tablets, shows that our model holds back to then [*Eos* **75**, No. 44, 75]. We conclude that conditions are ripe for producing more accurate 4000-year ephemerides, which would be og great value to the analysis of ancient astronomical records.

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