Myths and Maths of the Blessing of the Sun

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Judaism, like other ancient cultures, regards the March equinox, the beginning of northern spring, as the birthday of the Sun, and the notional beginning of the tropical year (a full cycle of seasons).

This is reflected in our calendar. Its year begins near the September equinox, but the March equinox is the notional and mathematical beginning of the "great solar cycle". This cycle is the basis for our computation of the *tekufot*, meaning the seasons and their beginnings, the equinoxes and solstices – the four "turning points" of the tropical year and of the Sun's apparent annual path around the ecliptic.

Some pagan religions celebrated this time of new growth and fecundity with annual fertility rites and festivals honouring the Sun (and other forces of nature) as powers in their own right. Judaism, believing in a Creator who is Master of the forces of nature, celebrates only special birthdays of the Sun – those that occur at a time of week connected with its creation. It turns this celebration into an act of worship of God.

That time of week is Wednesday at zero hours (i.e. at the very beginning of the day). When the March equinox occurs at that moment, Jerusalem time,* Jews gather together and thank God for the Sun with a blessing (called Birkat Hachama) praising Him for "performing acts of creation". (*We use Jerusalem time in all calendric calculations of global astronomical phenomena, like lunar phases and equinoxes, as opposed to local phenomena like sunrise and sunset.)

Why Wednesday? because in the biblical account of creation, the Sun was created on the fourth day. (I don't know the origin of the notion that this occurred at zero hours on that day.)

Zero hours here means 00:00, **Jewish Mean Time (JMT)**, i.e. as the hours of the day are counted in the Jewish calendar, in which the date changes at mean sunset – not six hours later at midnight, when the civil date changes. So Wednesday, 00:00, JMT = Tuesday, 18:00, civil time, and in general, JMT (in all places) equals (your local) civil time plus 6 hours.

For the purpose of this ritual, the March equinox is *deemed to occur* at the above time of week once every 28 years, making this the rarest liturgical observance in Judaism. It was last observed in the morning (at each location's local time) of Wednesday, 2009 March 26, **Julian**; 2009 April 8, **Gregorian**; 5769 Nisan 14, **Hebrew**. All over the world that week, Jews organised many large gatherings for this event, including, for the first time, one atop Masada.

I said above "deemed to occur" because for this, we use an artificially-computed, 'nominal' equinox (devised by **Shmuel**), which coincides only approximately with the real astronomical equinox. The real equinox will not occur at that exact time of week, Jerusalem time, with such regularity, if at all.

Shmuel, a third century talmudic rabbi and astronomer, wanted to fix regular dates for Judaism's two "moveable feasts" (if I may borrow the term) – this Birkat Hachama, and the annual commencement of the *sh'ela* season, the period of the year during which we add a request for rain to our daily prayers.

These two liturgical observances are entirely seasonal in nature, so they have no fixed dates in the Jewish calendar, whose months are lunar. Rather, they are governed by the equinoxes, and for this purpose, we use Shmuel's nominal equinoxes – *tekufot Shmuel*. Birkat Hachama occurs whenever the Shmuelian March equinox occurs at the above-mentioned time of week. *Sh'ela* in the diaspora commences annually 59 days after the Shmuelian September equinox.

Shmuel achieved his aim by basing his calculation of the *tekufot* on a tropical-year length of 365.25 days – the same as the mean year-length of the Julian Calendar (named after Julius Caesar who introduced it in 45 BCE). This had the deliberate effect of pegging these two "moveable feasts" to consistent dates in the Julian calendar, which, by Shmuel's time, had been in widespread use throughout the Roman empire for over two centuries, and, importantly for his purpose, was a solar calendar.

As a solar calendar, it is not very accurate. Because its mean year-length is longer than a tropical year, each season begins on progressively earlier dates in the calendar. Their start dates regress in the calendar at the rate of 7.8 days per 1000 years.

This was a problem for the Church, because it caused Easter to drift ever closer toward summer. Like Pesach, Easter is a northern spring festival and must occur shortly after the equinox. In 325, the council of Nicaea had irreversibly linked Easter not to the equinox itself, but to its presumed date, March 21. However by 1582 it was occurring on March 11.

To correct this, Pope Gregory 13th reformed the calendar. As a one-off adjustment he dropped 10 days from that year, and he changed the leap year rules so that the mean year-length became 365.2425 days, much closer to the length of a tropical year, which is about 365.24219 days. Pope Gregory's reforms became known as the Gregorian calendar – the civil calendar that is in almost universal use nowadays.

Shmuel knew that his year length was only approximate. A better approximation (365.2468222 days) had been found more than 300 years earlier by the Greek astronomer and mathematician, **Hipparchus**. Rav Adda bar Ahava, a contemporary of Shmuel, argued for the adoption of Hipparchus's year length, which eventually became the mean year-length of our present, fixed Jewish calendar.

But we retained the *tekufot Shmuel*, which were devised for calendric convenience, not for astronomical accuracy, so that our two "moveable feasts" could be pegged to consistent dates in a solar calendar, which is what Shmuel wanted to achieve.

This could only be achieved in the Julian calendar, whose leap year rule never varies (all years of the form 4n are leap years). Because of the variations to this rule in the Gregorian calendar, Shmuel's "great sun cycle" cannot be implemented in our

present civil calendar. This is why Jews still use the Julian calendar for these two observances. Birkat Hachama is always on March 26, Julian, in a Julian year of the form 28n+21.

The Smuelian *tekufot* currently occur about 18 days after the real equinoxes and solstices, a difference that keeps on growing. Eventually, if the rules are not changed, Shmuel's spring equinox will occur in the northern summer.

The first Shmuelian March equinox of the Jewish calendar is calculated to have occurred at zero hours (JMT) on Wednesday, March 26th of year −3759 (3760 BCE), Julian, which was Adar 22 of Jewish year 1. That date is the mathematical beginning of the "great solar cycle" of 28 years.

That's how long it takes for that *tekufa* to return to the same time of week. Here's why: The interval between a Shmuelian *tekufa* and the next one of the same type is 365¼ days, or 52 weeks plus 1.25 days. So the time of week of that *tekufa* advances each year by 1.25 days, or 125/100 days, per year. That fraction reduces to 25/20. Solve $Y \times 25/20 = W \times 7$ for the lowest possible integer values of years and weeks, and you get $Y=28$ and $W=5$, i.e. a cycle of 28 Julian years. So Birkat Hachama

occurs in Jewish years of the form 28n+1. (For year 1, n=0.)

Interestingly, according to traditional Jewish belief, the date of that first Shmuelian March equinox in Jewish year 1 is a purely theoretical date because it precedes the creation of the world, which took place in the last week of that year. The last day of creation, when Adam was made, was *Rosh Hashana* of year 2. So the first Shmuelian March equinox in year 1 is just a mathematical construct; the Sun did not yet exist then. The next Shmuelian March equinox (on Nisan 3rd, year 2) occurred on a Thursday at 06:00 (JMT).

The most oft-repeated claim about Birkat Hachama is that at the exact time of week at which it was created the Sun returns to the same place in the sky (as seen from Earth) that it occupied when first created. (That place is the March equinoctial point on the ecliptic, the Sun's apparent annual path around the sky. It crosses the Earth's equator at two points. The Sun is at this point at the March equinox, and it crosses the equator heading north.)

It should be abundantly clear now that although Birkat Hachama occurs near the beginning of northern spring, the above claim is a myth.

Since Shmuel's year length is longer than a tropical year, the Sun has never been at the March equinoctial point on any occasion of Birkat Hachama (nor was it there even in year 1 if it did not yet exist then). Nor has it been at exactly the same position *anywhere* on the ecliptic on any two occasions of Birkat Hachama (for the same reason).

Nevertheless, Shmuel's method is the best balance between astronomical accuracy and a practical cycle length for Birkat Hachama. Using a slightly better approximation of 365.24 days for the mean year-length, we find, by the method shown above, that the cycle length would be 175 years. A father, son and grandson might never see a single Birkat Hachama between them.

So Shmuel's method still serves us well. Not perfectly, now that our civil calendar is the Gregorian calendar, but well enough. However, there is no need to embellish it with myths like the one we have dispelled here. As Phillip Adams is fond of saying, "I can appreciate the garden without having to believe that there are fairies at the bottom of it."

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