The Concept of Time in Parma and Bologna: From Copernicus to Cosmology

June 14-22, 2014
About the cities that we will visit

Parma and Bologna are both located in the Italian region named Emilia-Romagna. Emilia is the western section which includes the provinces -- -West to East - of Piacenza, Parma, Reggio Emilia, Modena, Bologna and Ferrara. Romagna includes the eastern part of the province of Bologna and the provinces of Forlì-Cesena, Rimini and Ravenna. To the North, the natural line set by the Po river which flows West to East along latitude 45°, separates Emilia-Romagna from the regions of Lombardy and Veneto. To the South the crest of the Apennines separates it from Liguria, Tuscany and the Marches. To the West is Piedmont and to the East the Adriatic Sea. Most of the land in the region is very flat, sedimentary terrain, one of the richest agricultural areas of western Europe.

Emilia-Romagna is home to about 4 million people, mostly settled between the foot of the Apennines and the Po. All the provincial capitals, with exception of Ferrara and Ravenna, lie along a straight line running Southeast to Northwest from Rimini to Piacenza: the Via Emilia. One of the major Roman roads, it was built under the leadership of Consul Marcus Aemilius Lepidus the elder, starting around 187 before current era: BC), as the Roman Republic expanded to engulf northern Italy. Roman colonies populated the region, the major ones around fortresses (castra) located along the Via Emilia, separated from each other by about 25 km, a day’s march. They still remain the most conspicuous urban centers identifiable on the map: Piacenza, Fiorenzuola, Fidenza, Parma, Reggio Emilia, Modena, Bologna, Imola, Faenza, Forli, Cesena, Rimini. While much of the economy of the region is related to agricultural production, Emilia is home to highly specialized technologies, especially in the areas of food production, industrial ceramic and automotive. Notable names among the latter are Ferrari, Maserati, Lamborghini and Ducati, all located in the region between Modena and Bologna.

Map of Emilia-Romagna. From Google maps.
Parma endured the rough times following the fall of the Roman Empire, as did most settlements across Italy. It was sacked by the Huns led by Attila, destroyed by invading Gothic tribes and forced to choose sides – often the wrong one – during the struggles between Pope and Emperor in the Middle Ages. In the XII century, Parma and other cities in the so-called “Lombard league” gained rights to elect its own governing council and enact legislation, while still maintaining fealty to the Germanic Holy Roman Emperor. It was during the ensuing relatively quiet period that some of the monumental buildings in the city, including the Cathedral and the Baptistery, were built.

Political control in the “commune” cities like Parma did not extend very far from their protective walls. The boundaries between adjacent communes were uncertain and changeable as mini-wars of friction frequently flared up, and remote regions especially in the mountains were controlled by local feudal lords. In the XIV century, the Sforza family of the city of Milan had expanded its control to a fair fraction of the central Po river plain, including Parma, which is located 70 miles from Milan.

Such control was mediated by agreements with the local feudal families. Among the latter were the Rossi and Sanvitale, which respectively built the Torrechiara (left) and the Fontanellato (right) castles, both of which we shall visit. The latter houses a fresco by Girolamo Francesco Maria Mazzola, also known as Parmigianino. If you are in New York City before July 20, 2014, you might be interested in seeing the special exhibition at the Frick Museum on *The Poetry of Parmigianino’s “Schiava Turca”* (“Portrait of a Young Woman: Turkish Slave”, 1533. For further details, see [http://www.frick.org//exhibitions/parmigianino](http://www.frick.org//exhibitions/parmigianino).
Early in the XVI century, as a result of wars between major powers - the kingdoms of France and Spain and the Papacy -, Parma became part of the Papal States. In 1545, Pope Paul III, from the Farnese family of Rome, created the duchy of Parma and Piacenza, making Duke his illegitimate son, Pier Luigi Farnese. Through alliances and marriages, the Farnese of Parma became related with several major ruling families of Europe. In 1731, a diplomatic shuffle led to the transfer of the Duchy of Parma and Piacenza to the House of Bourbon.

The major “holding” of the Bourbons in Italy was the Kingdom of Naples and Sicily, however, which resulted into a sad episode that took place in 1734, when the outstanding art collections in the Duchy were moved to Naples. After 1748, the Duchy fell under French control and its administration produced much appreciated modernization.

Marie-Louise of Austria, daughter of the Emperor of Austria and second wife (divorced) of Napoleon, was Empress of France from 1810 to 1814 and Duchess of Parma from 1814 until her death in 1847. She was much loved for a period of relative peace and fair government. A museum dedicated solely to her and that period is located in the center of the city, in the vicinity of the opera theater (Teatro Regio), built in 1821 with the patronage of the Duchess. To date, the Regio remains one of the “altars of opera in Italy.

In 1860, Parma became part of the Kingdom of Italy. During the second world war, it suffered heavy allied bombing, which left in ruins some of its most important buildings. The remnants of the once huge Palazzo della Pilotta now host to the National Art Gallery, the Biblioteca Palatina and the XVII century Teatro Farnese, which we shall visit. A stone throw’s away from our hotel is the Auditorium Paganini, a concert theater recently converted from the historical industrial grounds of the pasta factory Barilla, now a major multinational based in the city. The University of Parma evolved from a school of liberal arts already active in the X century, although it never reached the importance of those of Bologna, Padua and Pavia.

The city of Parma has kept up its self-image of “capital”, albeit of what was a small, provincial but distinguished state. Today it is often referred to as the “Città Ducale” and even in sport commentary you can hear statements like “the boys of the Duchy just scored”. We like that.

Cremona is 40 miles from Parma, just across the Po river from Piacenza. While administratively located in Lombardy, it shares many characteristics with Emilian cities (some may say that Parma and Piacenza share many characteristics with Lombard ones; in the Middle Ages, in fact, they were members of the Lombard League of communes). The first Roman settlement North of the Po river, Cremona disappears from historical records after the fall of the Empire, It resurfaces late in the first millenium and plays an active role in the Lombard League of “communes” in the XII century. By 1301 it reached a population of 80,000, greater than the 70,000 of the present
day. It is during this period that the famous Torrazzo, the bell tower of the cathedral, was built. We will visit this extraordinary brick building, 370 feet high, within which is the largest “astronomical” clock in the world, initially built between 1583 and 1588.

Bologna is the largest city and the capital of Emilia-Romagna. With a metropolitan population of about 1 million, it dwarfs all other cities in the region, none of which exceeds a population of 200,000. An urban settlement was present at its site as early as the IX century BC. From the VII century BC on, it was known as the Etruscan city of Felsina, until Rome took it in 196 BC. Its early evolution is similar to that of other northern Italian cities like Parma: largely peaceful growth during the period of the pax romana, followed by long decline after the fall of the Roman Empire and resurgence as an independent commune and member of the Lombard League in the XI and XII centuries.

Bologna was the first in the world in declaring the abolition of slavery. The Liber Paradisus (Book of Heaven) is a 1256 law promulgated by the Commune of Bologna, The University of Bologna, founded in 1088, is reputed to be the first institution of its kind in the world and the model for other centers of knowledge. Think of the interesting coincidence of meanings of the words University and Universe. The etymology of the two words is the same; from Latin: unum vertere means “flow into one”. In the case of the Alma Mater Studiorum of Bologna, what was supposed to “flow into one” was the broad-minded study in synthesis of all liberal arts.

Notably, the city of Bologna was the first in the world in declaring the abolition of slavery. The Liber Paradisus (Book of Heaven) is a 1256 law promulgated by the Commune of Bologna,
which freed some 6,000 serfs in the city. Their liberation was paid by the Commune itself, at the market price, to the 400 lords who owned those serfs. The document is known as the Book of Heaven, with reference to the belief that God gave humans in paradise perfect and perpetual freedom. The city was also way ahead of others in Europe, in providing civil rights to women.

The XII and XIII century marked a period of great prosperity for the city, which reached a population of fifty to sixty thousand, placing it among the largest in Europe. The city was then also known by its towers, built by private citizens on their property. Two of the nearly 180 towers, which used to define the skyline of the city, remain proudly reminders of that epoch: the Garisenda and the Asinelli Towers stand next to each other in the very center of the city. The tallest (Asinelli) is 330 ft high. The view from the top is spectacular (but be warned: there is no elevator and the climb takes about 500 steps).

In the XIV and XV centuries, Bologna was ruled by two families: the Pepoli, from 1337 to 1401, and the Bentivoglio, from 1401 to 1506, at which time Pope Julius II besieged and took Bologna. For the following three and a half centuries, Bologna was part of the Papal State, with the exception of the brief interval during which Napoleon redrew Europe’s boundaries. In 1860, Bologna became part of the Kingdom of Italy.

The negative influence of the Church on the free flow of ideas had an impact on the acquisition of new knowledge, creative thinking and, ultimately, on technical and social progress. While the University continued to have keen minds among its faculty, the influential role the school – and the city - had across the continent before the takeover by the Papacy slowly waned. When we will discuss the achievement of Cassini in accurately measuring the parameters of Earth’s motions, be reminded of the intellectual circumstances in which a brilliant professor at the University did his work.

The flavor of Bologna’s urban character is notably unique. It is a city to enjoy discovering on foot, along its covered walkways (portici) built in the residential and commercial buildings. Some 25 miles of portici run within the area surrounded by the perimetral medieval walls (now mostly gone but its tracing is clearly evident in the town’s map). Or, as we enter for the first time the Piazza Maggiore, arriving from Via Clavature; that’s an experience that will remain with you for a long time.
A bit of background to the astronomical part of our trip

Using the Sun and the stars to measure time

<table>
<thead>
<tr>
<th>Celestial Sphere</th>
<th>Imaginary sphere centered on the Earth</th>
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<tbody>
<tr>
<td>North Celestial Pole (NCP)</td>
<td>Extension of Earth’s axis northward</td>
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<tr>
<td>Celestial Equator (Cel. Eq.)</td>
<td>Extension of Earth’s equator out onto celestial sphere.</td>
</tr>
<tr>
<td>South Celestial Pole (SCP)</td>
<td>Extension of Earth’s axis southward</td>
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To guide us in imagining the locations and motions of the Sun, Moon, planets and stars, we invoke the “celestial sphere”, an imaginary sphere whose poles lie along the extension of the Earth’s rotation axis and whose equator lies in the same plane as the Earth’s equator. At any point on Earth at any time, only some parts of the celestial sphere are above the local horizon.

- The stars have (essentially) fixed locations on the celestial sphere; whereas the Sun, Moon and planets move (with respect to the stars).
- The Sun, Moon, planets and stars rise in the east and set in the west daily because of the rotation of the Earth on its axis.
- The Sun drifts slowly eastward among the stars because of the yearly revolution of the Earth around the Sun.
- The rising and setting times of the stars change slowly but systematically through the year because of the motion of Earth around the Sun.
- An observer at any place on Earth views only those parts of the celestial sphere above the horizon at the time of the observations.
- The part of the sky above the horizon is different at each location on Earth and depends on the location’s latitude.

The Earth is tilted on its axis by 23½ degrees with respect to the plane of its orbit around the Sun. As a result, the Sun’s path across the sky varies systematically throughout the year, being higher and longer in summer than in winter. Of particular note to our interpretation of the Sun calendars, the noontime altitude (angular distance above the horizon) of the Sun in summer is 47 degrees (= 2 x 23½ degrees) higher than it is in winter.
Local View of the Sky

An observer at any place on Earth views only those parts of the sky above the horizon at the time of the observation.

**Altitude**: angular distance to an object in the sky up from the horizon.

**Azimuth**: angular distance along the horizon from the North point.

The altitude (angle upward from the North point on the horizon) of the NCP is equal to the latitude of the observer’s location. In Busseto, that is 45°. By geometry, the altitude of the point where the Celestial Equator crosses the meridian is also 45°. Because of the Earth’s axis tilt:

- **On Sep 21st** and Mar 21st, the Sun’s path follows the Celestial Equator; the noontime altitude of the Sun is 45°.
- **On Dec 21st**, the Sun crosses the meridian south of the Celestial Equator by 23½°, and the noontime altitude of the Sun is 45 - 23½° = 21½°.
- **On Jun 21st**, the Sun crosses the meridian north of the Celestial Equator by 23½°, and the noontime altitude of the Sun is 45 + 23½° = 68½°.
Noontime altitude of the Sun at Busseto

Spring and Autumn Equinoxes

Noontime altitude of the Sun is 45°.

Summer Solstice

Noontime altitude of the Sun is 68½°.

Winter Solstice

Noontime altitude of the Sun is 21½°.
The variation of the Sun’s noontime altitude is caused by the tilt of the Earth on its axis.
Because the height of the Sun above the horizon at noon varies throughout the year:

1. the length of day and night vary;
2. the angle at which the Sun’s rays strike the Earth varies, so that the amount of heating varies.

We experience seasons!

**Constellations and symbols of the Zodiac**
Because of the Earth’s revolution around the Sun, the Sun appears to drift slowly among the stars in an eastward direction over the course of a year. Its apparent path among the stars traverses the constellations of the zodiac.
Busseto and its Sundial

Constellations and symbols of the zodiac
The Sundial in Busseto

Busseto is located at
latitude 44.98° N
longitude 10.05° E

This one is a vertical sundial which faces S-SW.
Notice that the gnomon (the part of the sundial that casts the shadow) is offset from the central vertical line because the wall does not face directly south.
The Sun’s position on a given day varies a bit from what would be simply predicted; this variation is traced by the analemma and arises not only because the Earth is tilted on its axis by 23½° relative to the plane of its orbit around the Sun, but also because the Earth’s orbit around the Sun is elliptical, not circular.

**The equation of time**

The difference between the mean solar time (a smooth average over the year) and the apparent solar time (on any day) is known as the “equation of time”. From [http://star-www.st-and.ac.uk/~fv/webnotes/chapt10.htm](http://star-www.st-and.ac.uk/~fv/webnotes/chapt10.htm).
The Palazzo del Governatore in Parma
The analemma in the front of the Palazzo del Governatore in Parma is a graph of the variation in the angular displacement of the shadow of the Sun, measured at noon throughout the year, with respect to the mean position as measured by a clock.

The “equation of time” provides the East-West component of the analemma graph. The North-South component of the analemma corresponds to the seasonal apparent displacements of the Sun.
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The Torrazzo of Cremona

The Torrazzo of Cremona is the bell tower of the Cremona Cathedral. It is 112.7 meters (343 ft 6 in) high, making it the third tallest brickwork bell tower in the world and the oldest brick structure taller than 100 meters high that is still standing.

According to popular tradition, construction on the tower began in 754. In reality, it was built in four phases: a first dating back to the 1230s, up to the third dripstone, a second, between 1250 and 1267, up to the dripstone under the quadriphore, a third around 1284, and finally, the completion of the marble spire in 1309. (Based on wikipedia)

In the Torrazzo’s fourth story resides the largest astronomical clock in the world. The mechanism was built by Francesco and Giovan Battista Divizioli (father and son) between 1583 and 1588. The exterior, originally by Paolo Scazzola in 1483 but later repainted many times, represents the sky with Sun and Moon moving through the constellations of the Zodiac.

The clock’s dial, or planisphere (see images on the next page), is 8.4 meters (27.7 feet) in diameter; embedded within it are a number of rings marking different measures of time. The outermost ring shows the hours of the day from I to XXIV in the Latin tradition, while the 2nd one marks the Zodiac constellations, also in the Latin custom. The next rings subdivide into finer divisions (degrees, decimal degrees). The colored 5th ring shows the Zodiac constellations and bright stars. The 6th and 7th rings show the months, in Latin, and days. The central rings trace the lunar phase; how much of the Moon is illuminated in its current phase is also depicted.
The following information is provided for Cremona (longitude E10.0, latitude N45.1):

<table>
<thead>
<tr>
<th>Wednesday</th>
<th>18 June 2014</th>
<th>Universal Time + 2h</th>
</tr>
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</table>

**SUN**
- Begin civil twilight: 04:55
- Sunrise: 05:32
- Sun transit: 13:21
- Sunset: 21:10
- End civil twilight: 21:47

**MOON**
- Moonset: 10:39 on preceding day
- Moonrise: 00:15
- Moon transit: 05:59
- Moonset: 11:52
- Moonrise: 00:48 on following day

Phase of the Moon on 18 June: waning gibbous with 65% of the Moon's visible disk illuminated.

Last quarter Moon on 19 June 2014 at 20:39 (Universal Time + 2h).
Cassini’s meridian in the Basilica of San Petronio, Bologna
Parma (pop. 187,000)
- Founded by Etruscans, later a Roman colony.
- 1545: became duchy (along with Piacenza) under Farnese family
- 1731: sold to House of Bourbon in 1731
- 1814: Maria Luigia (2nd wife of Napoleon) rules until her death in 1847
- 1860: joined unified kingdom of Italy
- 2010, 11, 12, 13: American Football Champions

- Duomo: completed 1178; paintings by Correggio and others
- Battistero: completed 1216; spectacular cupola
- Camera di San Paolo: Room in convent decorated with frescoes by Correggio (1519)
- Teatro Farnese: Built 1617 in wood. Bombed in WW2 but nicely reconstructed

The K2 gelateria near the Cathedral and Battistero is also worth a visit.

Castello di Torrechiara
- Built 15C by Pier Maria Rossi as “love nest” for his lover Bianca Pellegrino, overlooking Parma valley and foothills
- Camera d’Oro: decorated by Bonifacio Bembo (lower right)
- The 1985 movie “Ladyhawke” was partly filmed there (Matthew Broderick; Michelle Pfeiffer)
**Cremona** (pop. 70,000)
- Cremona boasts the world’s (physically) largest astronomical clock, found on the world’s 2nd tallest brick bell tower. It also has a long musical tradition and remains a center for the production of finest quality violins.

**Fontanellato** (pop. 6600)
- The town is centered on the moated Rocca Sanvitale.
- Inside are frescoes painted in 1523-4 by Parmigianino.

**Brisighella** (pop. 7800)
- Small town south of Bologna in the province of Ravenna in Romagna, surrounded by 2 steep hills and famous for its olive oil.
- View of the town from the Torre dell’Orologio (upper left)
- View of the Torre dell’Orologio from the Rocca (bottom right)
- We will stroll along the covered Via degli Asini (Donkey’s Road)
**Dozza** (pop. 5900)
- A small hill town near Bologna with spectacular views of the countryside (bottom left).
- The walls are covered with artwork (left) painted as part of an art contest every other year.
- At the entrance to the town is the Rocca in whose cellar is the Enoteca Regionale Emilia Romagna (wine tasting bar).

**Bologna** (pop. 380,000)
- We will stroll along the covered porticoes.
- The Basilica of San Petronio (begun 1390) houses the meridian line traced by Cassini in 1655.
- The Museo della Specola (unfortunately now closed for renovation) occupies the tower (1725) in the main building of the university where both Riccardo and Copernicus studied (not at the same time).