BRIEF

TIME

What is BJD (Barycentric Julian Date)

Overview

Barycentric Julian Day – The current day and time at the center of the Solar System

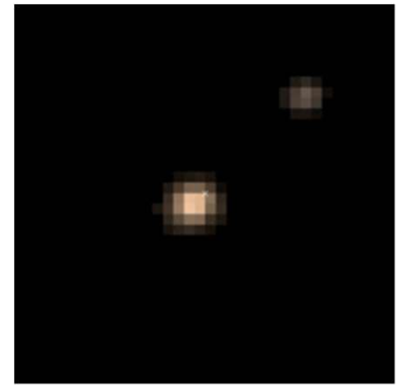
What is a Barycenter

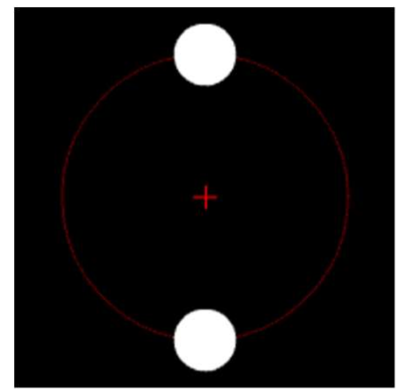
A Barycenter is the center of mass between two objects.

From the combination of Kepler and Newton, we know that objects orbit around a common Focus within an Ellipse.

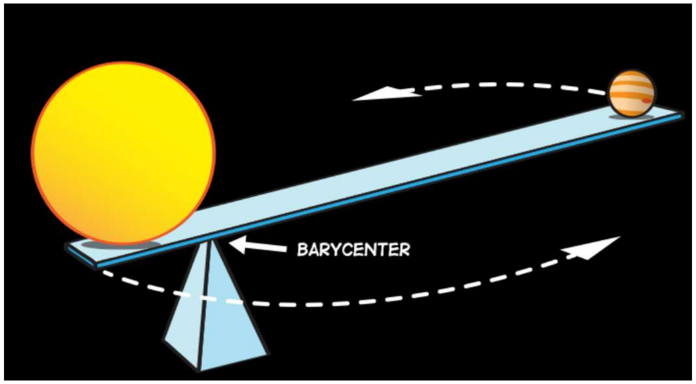
The more massive object is closer to this focus position.

However, the exact focus is the center of mass between the two objects: The Barycenter





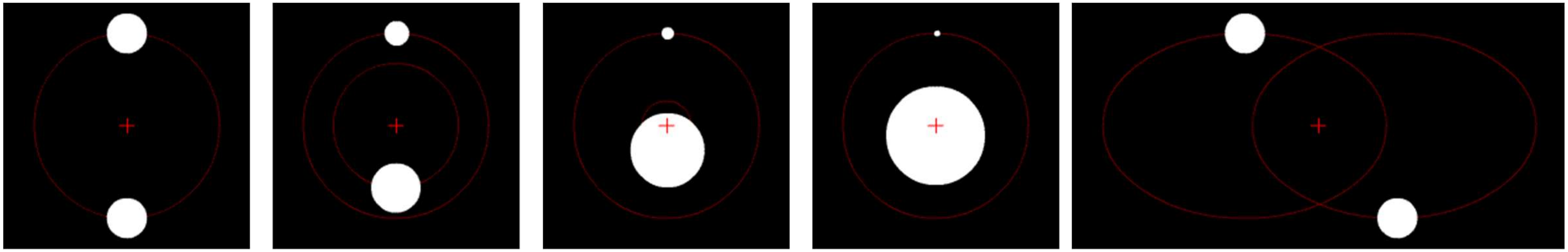
What is a Barycenter



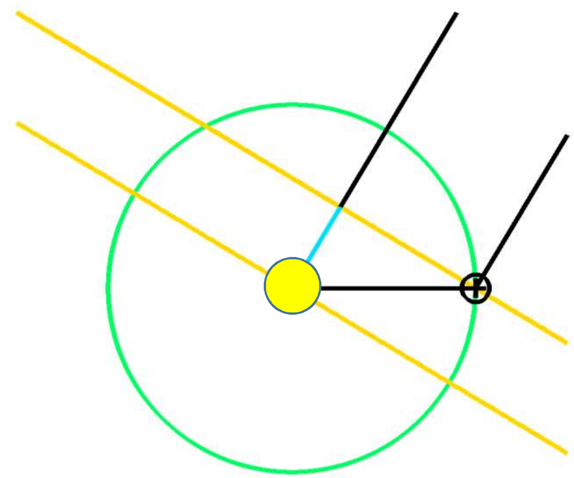
In cases where one body is much more massive than the other, the Barycenter often lies within the radius of the more massive object.

In other cases, those of more equal mass, the Barycenter will usually lie nearer to a mid point between those objects.

The series of images below, Source: Wikipedia, provide great visuals of how the Barycenter varies with mass differentials.



How does the Barycenter relate to Date and Time



Barycentric Julian Date (BJD) is simply the Julian Date (JD) corrected for differences in the Earth's position with respect to the barycenter of the Solar System.

Due to the finite speed of light, the time an astronomical event is observed depends on the changing position of the observer in the Solar System. From an Earth – Sun perspective, this can vary by ±8.3 min (~500 seconds).

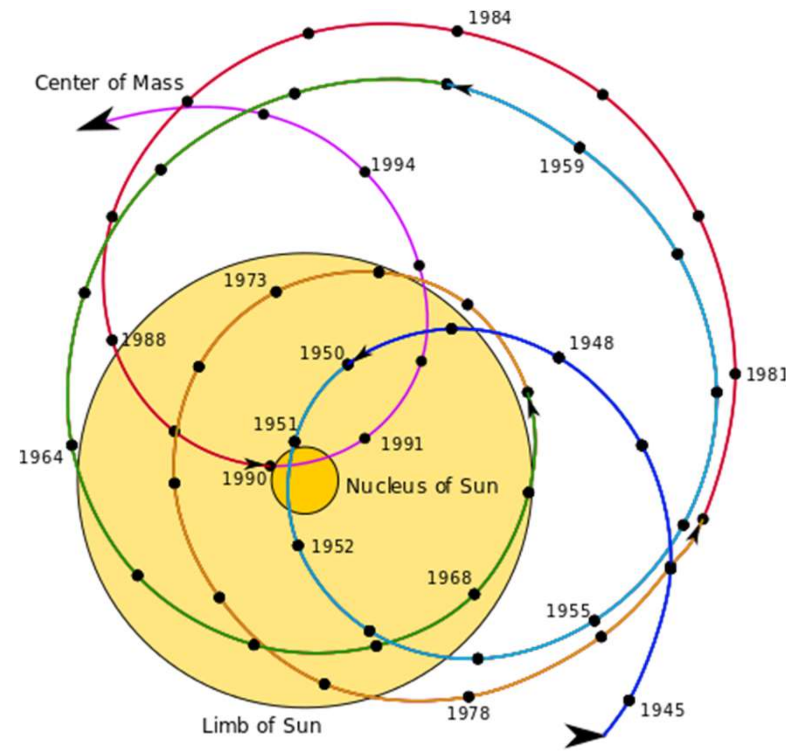
How does the Barycenter relate to Date and Time

Before multiple observations can be combined, they must be reduced to a common, fixed, reference location.

This correction also depends on the direction to the object or event being timed.

BJD is different from the Heliocentric Julian Date (HJD) which relies on the center of the Sun.

The difference in timing between the center of the Sun and the Barycenter, thus HJD to BJD, is up to ±4 s.



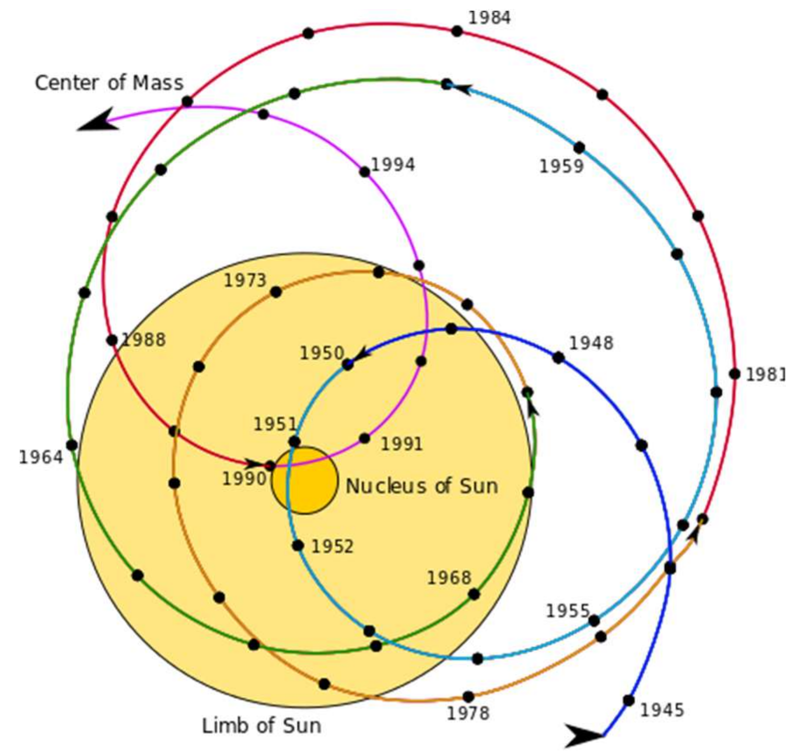
How does the Barycenter relate to Date and Time

Quality data and observations demand precision and standardization.

Prior to the last decade, the observations with the greatest demand in accurate timing were Pulsars.

Now, Exoplanet observations demand the same precision.

Especially when we consider that slight variation in transit timing could have significant implications on the system being observed: Need to refine the orbit, which leads to mass changes, or even other bodies in orbit affecting orbit periods.



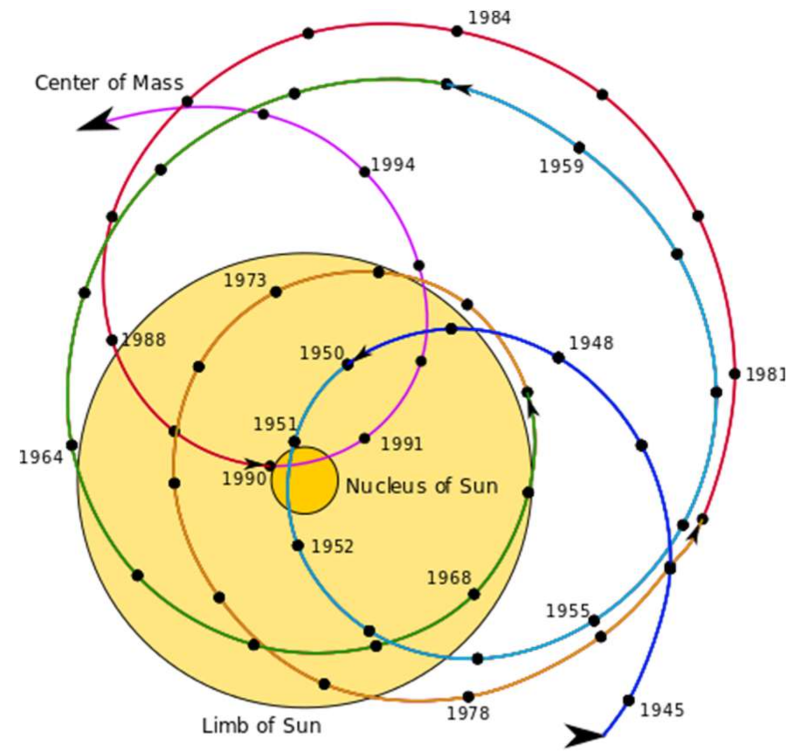
BJD to BJD_TDB

Without standardization in Exoplanet timings, significant confusion can arise around the nature of the system.

When imaging a target, the current time will be recorded in the FITS file, assuming the imaging computer is sync'd to an accurate clock (there is a video on this).

This time can be converted to BJD.

To further hone in on an accurate time BJD_TDB, the Barycentric Julian Date in the Barycentric Dynamical Time has been developed as another standard for any astrophysical event.



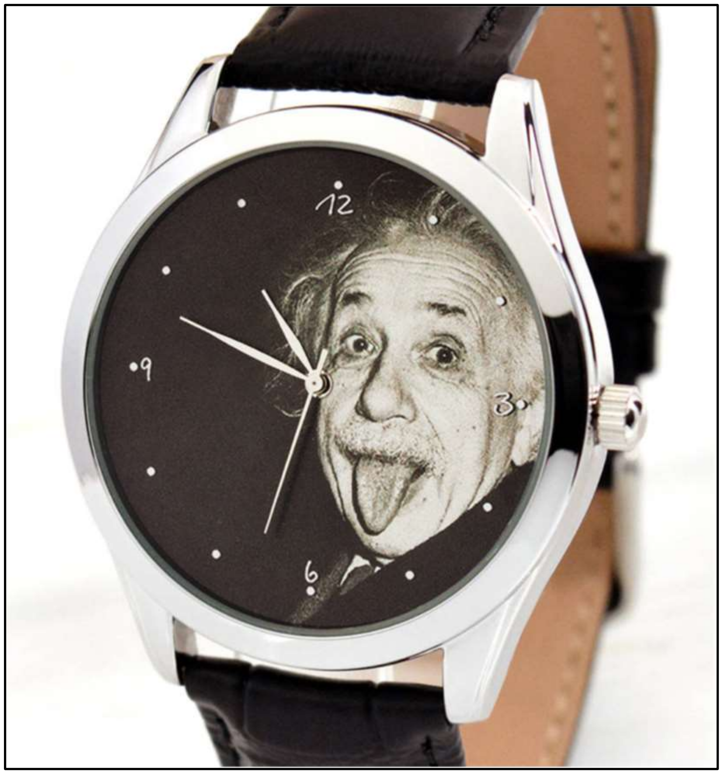
BJD to BJD_TDB

Barycentric Dynamical Time (TDB) takes into account Relativity -
- the fact that moving clocks tick at different rates.

As the Earth moves, our atomic clocks actually change rates.

Enter TDB: a truly uniform time, as would be measured it on Earth if it were not moving around the Sun or being pulled by the Moon and other celestial bodies.

The Barycentric Dynamical Time (TDB) is the best to use in practice for Exoplanet observations.



Other forms of BJD

BJD_UTC: BJD expressed in Coordinated Universal Time that is used to provide a time that is universal to all time zones on Earth. It is the international standard on civil time on Earth

BJD_TT: Terrestrial Time, established by the International Astronomical Union to provide a means to denote a time measurement for astronomical observations made from Earth.

Questions?