Stellar Metamorphosis: Differential Rotation in Stars

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Abstract: Differential rotation is when a portion of a star rotates faster than another. With young stars like the Sun, this is more pronounced, with the equatorial angular velocity being higher than the polar angular velocity. The angular velocity remains differential between the poles and equator when the star is young, and then equalizes as the star evolves. This means the oldest stars will not have differential rotation (as well as no global magnetic activity), and the youngest will have the most pronounced. Explanation is provided.

The Sun's equator rotates once about every 24.47 days. Its poles about 38 days per rotation. This is because it has no core, and is a fluid body (it is composed of either liquid, gaseous or plasmatic material). As well, it is simple engineering to note that fluids experience no sheering forces, unless there is a boundary. Formation of a boundary causes a no-slip condition, which the fluid relative to that boundary will have zero-velocity.

Jupiter's polar rotation takes about 5 minutes longer than its equator, which signals it is much more viscous in its interior than the Sun, though does not have a no-slip condition because no solid boundary yet exists. This is expected because the Sun is a plasmatic homogeneous body (same throughout) and Jupiter is slightly differentiated with a very large liquid interior. Jupiter (632-731 million years old) http://vixra.org/pdf/1905.0467v1.pdf is much more evolved than the Sun as is evidenced by the equatorial and polar angular velocities almost matching. Though, it still does not have a solid interior, so any reduction of its differential rotation is mostly caused by internal friction between fluids of different viscosities.

Only the old stars have evolved enough to form solid crusts internally will begin the process of completely removing differential rotation, and then experiencing some form of sheer stress. Though when a star is in Neptune stages of evolution, the rate at which it can reduce the differential angular velocities would be to introduce a no-slip condition (the formation of a solid interior). Less interaction between fluids could cause this. Angular velocities would match with more fluid interaction, but speed up if the collapse happens simultaneously as solid surface (crust) formation. We can physically determine if a star is extremely old by measuring its differential rotation.

Of course this is a generalization and has to be adjusted for the total size of the body, and the layers with which friction can occur, as well as past orbital history. Orbital changes can cause there to be tidal friction on both deep interior and the mantles/atmospheres of the objects. Differential rotation could be more pronounced in objects like Neptune, but that is due to external factors that occurred in the objects past, as well as changing fluid densities as the star evolves.

One could say that differential rotation in smaller gaseous bodies that have evolved greatly can be subjected to the gravitational fields of larger bodies. This being said, atmospheric differential rotation ceases to be noticeable as physical movement when the star loses its thick gaseous atmosphere, as well develops a large solid internal region. This means differential surface rotation will be nearly impossible, and the star will more than likely just experience internal differential rotation, due to internal magma (liquids). This was originally hypothesized in the paper titled, "Inertial Core Theory", here: http://vixra.org/pdf/1209.0080v2.pdf The only way to continue to tell if there is differential rotation internally after the crust has formed would be to measure the strength of the magnetic field.

This is not to say there cannot be differential rotation inside of the thin atmosphere such as the Earth due to solar heat dissipation and the whole bodies rotation. I am only referencing whole body differential rotation, as if the land itself was constantly moving as if we were standing on huge oceans of lava.

As well, the production of magnetic fields rests on differential rotation. If a star does not possess a strong global magnetic, i.e. Venus, Mercury or Mars, then we can guarantee there is very little internal differential rotation. With little internal differential rotation underneath the solid crusts, we can also hypothesize that there is very little liquid material (meaning the star has been solidifying internally). Continuing, we can also hypothesize that their interiors have had extremely long periods of time to cool down from earlier stages of evolution. This also takes into account that the rate of heat loss would be incredibly slow, due to the thickening crust trapping the heat from flowing back into interstellar space in all forms, radiative, convective and conductive. This follows from the measurements of Venus's and Mars' atmospheric D/H ratios, as they have already been shown to be 450-702 billion years old (Venus) http://vixra.org/pdf/1905.0251v1.pdf and 21.33-30.65 billion years old (Mars) http://vixra.org/pdf/1905.0369v2.pdf.

Objects that have had tens of billions to hundreds of billions of years to cool off, have indeed cooled off. When we start measuring the magnetic fields of exoplanets (evolved stars) that are Earth sized, their magnetic fields will be the bread and butter of the observations. No magnetic field, equals no interior fluid motion, equals the star is dead and does not host life. This is to pit against the hypothesis of the habitable zone, which does not include the actual physical age or most of the physical characteristics of the star (mass is only one physical characteristic). A star the size of Earth (Venus) in this example could be >100 times older. Watering a dead plant won't make it grow as much as placing a dead star like Mars or Venus in the habitable zone will make life spring forth or even sustain it. Both have completely different atmospheric pressures, one is too great, the other too diffuse.

A star's atmospheric and deep interior differential rotation can be used to determine how old it is. So for this paper the extremes are outlined, the Sun is very, very young, probably a couple million years old, max 100 million, and Venus is very, very old, probably >450 billion. From that we have a very different portrait of the star system we live in. All stars will have some kind of differential rotation as well, we can use this fact to add to our tool box of determining how much life is out there, and what stars are actually doing.