Review Article

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Ring currents induce the solar magnetism and cause the oscillations in brightness

Abstract

Recent observations with the NASA'a Solar Dynamic Observatory (SDO) revealed that magnetic fields rule the solar dynamic. These magnetic fields result from ring currents induced by the different angular velocity of different layers of the spinning sun. The article is about these ring currents, which can give us information about the structure of the sun and its layers in depth. We offer in this article a better model of the ring currents, which better reflects the solar dynamic, than Dr. Zhao's model. We also offer explanation of the observed oscillations in the brightness of the sun and we don't think it is a systematic error in measurements, as Dr. Zhao thinks. We consider the oscillations in brightness result from Doppler Shifts (of the spectral lines) in opposite direction for clockwise and counterclockwise ring currents.

Keywords: solar magnetism, ring currents, revealed solar structure, oscillations in solar brightness, Doppler shifts and oscillations in brightness

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Introduction

T Candell & H Hill[1] wrote in the Encyclopedia of Physics in 1990: "the Sun has been discovered to oscillate with small amplitude global normal modes with periods ranging from a few minutes to several hours. Observations of global oscillations have the potential of giving information… on all layers of the Sun." They "will allow detailed tests of the models of the solar interior." This is a genius insight into the matter more than 20 years ago. Let us look at some later results.

NASA's Solar Dynamic Observatory (SDO), launched in space in 2010, has on its board Helioseismic and Magnetic Imager (HMI) taking high-resolution photos of the solar surface. We hope to learn from them more about the origin of the solar magnetism and activity, which reflect the solar structure and dynamic.

The observed oscillations in brightness

A. Smart in an article published in Physics Today[2] reveals that Junwei Zhao et al.[3] when reviewing the solar HMI images collected for 10 days in December 2010, found periodic changes observed as oscillation of the brightness of various spectral lines. The team also calculated the eastward velocity along the solar equator from the HMI images. The analysis found larger than average velocities in the east half of the solar disk and smaller than average velocity in the west half, but there were also oscillations in brightness. Junwei Zhao et al.[3] assumed systematic error in the measurements in both directions: surface to center and along the equator in direction west east. However, they couldn't understand what is causing these oscillations. The author of this article thinks this is not a systematic error and offers explanation to it.

Zhao postulated three areas with alternating in depth ring currents

Junwei Zhao et al.[3] interpreted the helioseismologic time-distance measurements (of the solar subsurface velocities) as existence of at least three different areas in depth of alternating ring currents, which create magnetism with opposite polarity:

a) A meridianal flow of plasma moves on the surface toward the poles, and back in deeper area, at depth R_0 - 0.9 R_0, forming a closed circle.

b) Another meridianal flow moves circularly under it in the opposite direction, toward the equator and back in depth 0.9 R0 - 0.8 R0.

c) A third meridianal flow moves circularly toward the poles again and back in depth 0.8 R_0 - 0.7 R_0 (R_0 is the radius of the Sun). This is the limit of the recent studies (Figure 1 for the first two layers).[4] On the surface of the Sun along the equator, aligned couples vortex – anti-vortex is observed. This means that the Sun has alternating zones with opposite magnetic polarity not only in direction surface – center, but also along the equator. Therefore, zones with alternating opposite magnetic polarities, which are product of moving in opposite direction ring currents, must be present in both solar depth and parallel to the solar equator.

Revision of the ring currents proposed by Junwei Zhao et al.[4]

During solar activity, observations show maximal number of solar spots in the equatorial areas of the sun, which are 30° north and south of the equator. Since the solar spots are the openings of vortices sucking energy in and anti-vortices throwing energy out, this is the active turbulent zone of the Sun. If so, the ring currents, which Junwei Zhao et al.[4] postulated (presented on Figure 1), cannot expand all the way to the poles. The active turbulent equatorial zone (0° – 30°) should have separate ring currents and they should be larger and more numerous than the ones in the zone 30° to 60° (Figure 2).

Also, Pastor Abar et al.[5] (by using SDO's Helioseismic and Magnetic Imager data) found that the spinning period of the sun varies with the latitude: it is 25.5 days at the equator and 34.4 near the poles. The faster spinning of the Sun in the equatorial area would induce more turbulence and more ring currents there. This could explain the observed larger number of vortices and anti-vortices (called solar spots) in the active equatorial zone of the Sun (0–30°) during solar activity (Figure 2).

Also, long-term observations of the solar activity indicated that solar spots are first observed at higher latitudes at the beginning of each cycle of solar activity.[2] Then as the cycle of activity advances, solar spots are observed at lower latitudes, i.e. closer to the equator.[2] This could be explained only if the postulated ring currents of Zhao (Figure 1) are modified into two different sets of ring currents - for the equatorial zone and for higher latitudes - as they are on Figure 2.

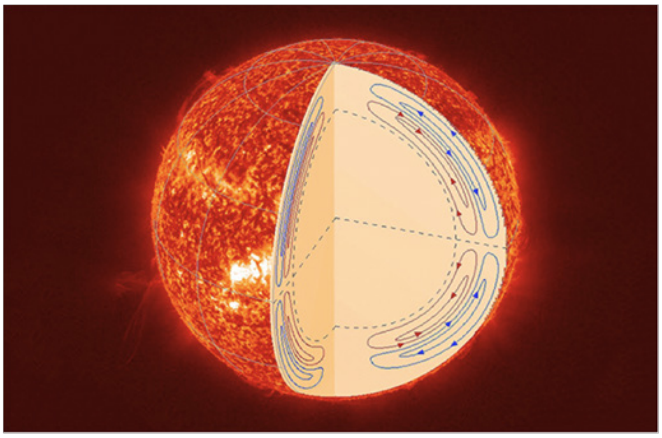

Figure 1 Two of the meridianal flows of solar plasma in depth as postulated by Dr. Zhao.[4]

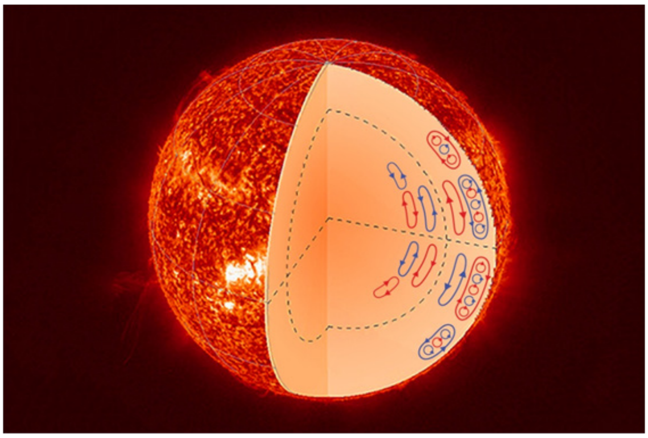

Figure 2 Higher solar activities in the equatorial area of the sun is considered to impact the meridianal flows of solar plasma in depth.

In this article, the observed higher solar activity in the equatorial area of the sun is considered to impact the meridianal flows of solar plasma in depth. Since each cycle of solar activity first starts with flares observed at higher latitudes[2] and much later in the equatorial area, this means that the solar activity starts in deeper areas of the Sun. Why? Because the deeper ring currents, being with smaller radius and thus weaker, would be first influenced by external magnetic perturbations.

Explaining the oscillations in brightness as Doppler shift lines

Junwei Zhao et al.[3] couldn't explain the observed periodic oscillations in solar brightness. Not understanding what is causing the effect, they assumed systematic error in the measurements in both directions: surface to center and along the equator in direction west east. The author of this article thinks that this is not a systematic error and offers explanation to it. Doppler shift of spectral lines was first observed when the source of light or the receiver was moving further apart or closer. Bruce A Garetz et al.[6] demonstrated that Doppler shift could also be observed when a laser light is circularly polarized. He even found that the Doppler shift of circularly polarized light is proportional to its rotational velocity.[7] Sagnac G[8] found that a light, which is circularly polarized in counter-clockwise direction, is Doppler shifted to lower frequencies, while a light circularly polarized in clockwise direction is shifted to higher frequencies. It is called Signac effect. On the basis of this discovery, rotating ring interferometer was created for measuring Doppler shifts, in which the angular velocity of the set up apparatus is proportional to the Doppler shift.

If spectral lines are Doppler shifted to higher frequency when the light is circularly polarized in clockwise direction, such Doppler shift to higher frequencies must also be observed when ring currents running in clockwise direction are present. If the spectral lines are Doppler shifted to lower frequency when the light is circularly polarized in counterclockwise direction, such Doppler shift to lower frequencies must also be observed when ring currents running in counterclockwise direction are present (see farther explanations below why this is so). Thus, the spectral lines Doppler shift to higher frequencies when the ring currents spin clockwise and Doppler shift to lower frequencies when the ring currents spin counterclockwise. This must be observed for both: the ring currents in depth and the ring currents along the equator, which would explain the observed oscillations in solar brightness in both directions – depth and east west.

To explain why the spectral lines shift to higher frequencies when the ring currents spin clockwise, let us determine the direction of the magnetic field induced by clockwise running ring currents. According to the rule of the folded fingers of the right hand, when the folded fingers of the right hand are in the direction of the clockwise running ring currents, the induced magnetic field is toward the sun. Magnetic energy would be added to the sun, which would Doppler shift the spectral lines to higher frequencies. To explain why the spectral lines shift to lower frequencies when the ring currents spin counterclockwise, let us determine the direction of the magnetic field induced by counterclockwise running ring currents. According to the rule of the folded fingers of the right hand, when the folded fingers of the right hand are in the direction of the counterclockwise running ring currents, the induced magnetic field is off the sun. Magnetic energy would be subtracted from the sun, which would Doppler shift the spectral lines to lower frequencies.

Thus, clockwise running ring currents must Doppler shift the spectral lines to higher frequencies, while counterclockwise ring currents must Doppler shift the spectral lines to lower frequencies. The Doppler shift would be proportional to the spinning velocity of the ring currents and could be used to determine the spinning velocity. It will be observed as oscillation in brightness of the solar image - it is not a systematic error as Zhao and his team think.[4]

As said, each cycle of solar activity first starts with flares observed at higher latitudes[2] and much later in the equatorial area. This means that the solar activity starts in deeper areas of the Sun and the alternating in depth zones with opposite polarity project onto the solar surface as alternating vortices and anti-vortices in direction equator

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– poles. The alternating along the equator vortices and anti-vortices in the equatorial zone mean alternation in direction east west. As a result, the sun will look like a checkerboard with possible vortices in the black squares sucking energy in and anti-vortices in the white squares throwing energy out. This will be mostly in the equatorial area. To complete the review, we must say that Pastor Yabar et al.[5] tried to explain the observed short-term oscillations, which they found to be specific not only for the active equatorial area, but also for higher latitudes, as caused by variations in the misalignment of the Sun's rotational and magnetic axes. For me, this explanation is very questionable.

Conclusion

Recent observations revealed that magnetic fields rule the solar dynamic. These magnetic fields result from ring currents induced by different angular velocities of different layers of the spinning sun. If so, these ring currents can give us information about the structure of the sun and its layers in depth. The offered here model of the ring currents of the Sun in depth reflect better the solar dynamic than Zhao's model.

Explanation was also offered of the observed oscillation in solar brightness and we don't think it is a systematic error in measurements as Junwei Zhao et al.[3] thinks. The oscillations in brightness were explained as Doppler Shift of the spectral lines to higher frequency for clockwise running ring currents and Doppler Shift of the spectral lines to lower frequency for counterclockwise running ring currents. It was also explained why the spectral lines Doppler shift to higher frequencies at clockwise running ring currents and Doppler shift to lower frequencies at counterclockwise running ring currents.

Acknowledgments

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Conflicts of interest

Author declares that there is no conflict of interest.

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