**Article**

# The Voids between Galaxy Clusters and the Chirality of Spiral Galaxies

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**Abstract**
A study of the Sun's corona reveals that the velocities of electrons are substantially higher than the velocity of escape and the velocities of protons are well below the velocity of escape. In a previous paper it was deduced that these circumstances cause hot stars, such as the Sun, to hold a net positive electric charge, otherwise hot stars would lose all their electrons. This positive charge dominates the orbital velocities of stars in a galaxy. It was also deduced that orbiting stars would create a magnetic field. It follows that clockwise and anti-clockwise spiral galaxies would repel each other. The Galaxy Zoo was applied to this study. It was predicted that opposite edges of voids between clusters would contain spiral galaxies of opposite chirality. This prediction is now verified. The success of this prediction provides a reason for challenging the dark matter theory.

**Keywords:** Sun corona, dark matter, missing mass, galaxy clusters, spiral galaxies, voids, chirality.

## 1. Introduction

This is the third paper in a series on the subject that the Sun contains a net positive electric charge.

The first paper (Bligh, 2010) deduced that hot stars such as the Sun hold a small positive electric charge. The reason is that the temperature of the corona, which is ionized, is at least $1.1 \times 10^6$ K. At this temperature 99% of the electrons have velocities greater than the velocity of escape; less than 0.0001% of protons have this velocity. These facts are evident from the Maxwell-Boltzmann Distribution curves. Superficially this leads to the conclusion that the Sun would lose **all** its electrons and **none** of its protons. Obviously this does not happen. It follows that during the early history of the Sun, it lost a small proportion of its electrons such that it became positively charged. This net positive charge holds back most of the electrons from escaping into space and also this positive charge repels a small proportion of protons into space such that the Solar Wind contains an equal balance of electrons and protons. This theory has a lot of support from other observations which are given in the first paper and will not be reiterated here.

The second paper (Bligh, 2012) dealt with the phenomenon that the Sun is an almost perfect sphere, which is in contrast to rotating planets which are oblate (Kuhn, 2012). The explanation is that the electric charge on the Sun is uniform and it creates internal repulsion which pushes out the surface of the Sun and this repulsion overrides a centrifugal force, which would otherwise have made the Sun oblate. It was predicted in the first paper that lone brown dwarfs, which do

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not have the high temperature of the Sun, would have orbital velocities below the so-called "flat rotation curve" in galaxies. This has been shown to be the case. I made the second prediction "that spiral galaxies separated by voids between clusters will be found to have opposite orientations". The present study is to test this prediction.

## 2. The Theory

It is standard Physics that moving electric charges create a magnetic field. It follows that hot stars, such as the Sun, will create a magnetic field as they orbit in a galaxy. It then follows that there will be interaction between the magnetic fields of neighbouring galaxies; galaxies having the same rotational sense will attract each other and those with an opposite sense will repel each other. It was predicted that spiral galaxies separated by voids between clusters will be found to have opposite chirality. The Galaxy Zoo project provides the means for testing this theory.

## 3. Method

The Sloan Digital Sky Survey, Data Release 7, provides information on stars and galaxies for a quarter of the northern Sky (SDSS, DR7). The Galaxy Zoo is a project (Lintott et alia, 2011) in which galaxies were observed in SDSS and the types were put into one of 6 categories:

Elliptical galaxy,
Clockwise spiral galaxy,
Anti-clockwise spiral galaxy,
Other galaxies, e.g. edge-on,
Uncertain,
Merger.

In order to test the prediction, a galaxy system was found in a paper by Cedres et alia (2009) on the Hercules cluster. Their figure 2 presented contours which indicate the density of galaxies, extracted from 2MASS database. These contours showed where there are voids.

In the present exercise SDSS, DR7 was used to find galaxies and record their properties, which are:

Identification Number (ObjID),
Right ascension (RA),
Declination (Dec),
Redshift (z)
Magnitude.

Each galaxy was then re-identified in Galaxy Zoo database by means of its ObjID, RA and Dec. This data base (which is a massive table) provided code numbers describing each galaxy as - elliptical, clockwise spiral, anti-clockwise spiral, edge-on or "uncertain". The detailed method of carrying out this search is given in the appendix.

The computer screen directed at SDSS, DR7 could be made to cover a square 0.04 degrees(RA) x 0.04 degrees(Dec). In practice the screen nearly always showed one or two galaxies even although these were very faint. These faint galaxies were irrelevant to the present study and were ignored. It is apparent that these faint galaxies are not part of the Hercules cluster, - and anyway they do not appear in the Galaxy Zoo tables. An area of space was covered in strips – sometimes from north to south and sometimes from east to west. In this way the whole of Cedres figure 2 was covered.

It was found that most of galaxies under consideration had values of z between 0.031 and 0.040. SDSS, DR7 turned up some galaxies with z in the range 0.10 to 0.14 but it is assumed that these are not in the Hercules cluster, and anyway many of them are not in the Galaxy Zoo table, so they would not have been useful in the present study.

The galaxies identified as “elliptical”, “edge on” and “uncertain” were put into one group and the other groups were clockwise and anti-clockwise. These are plotted into the diagram. The diagram requires careful study in order to be appreciated. For example two galaxies at RA = 241.530, Dec = 17.461 appear to be very close together; actually the anti-clockwise spiral galaxy is much closer to Earth than the other galaxy.

The first conclusion is that the distribution of galaxies revealed by SDSS, DR7 followed closely the contours in Cedres figure 2. This observation provided confidence that the present study is along the right lines.

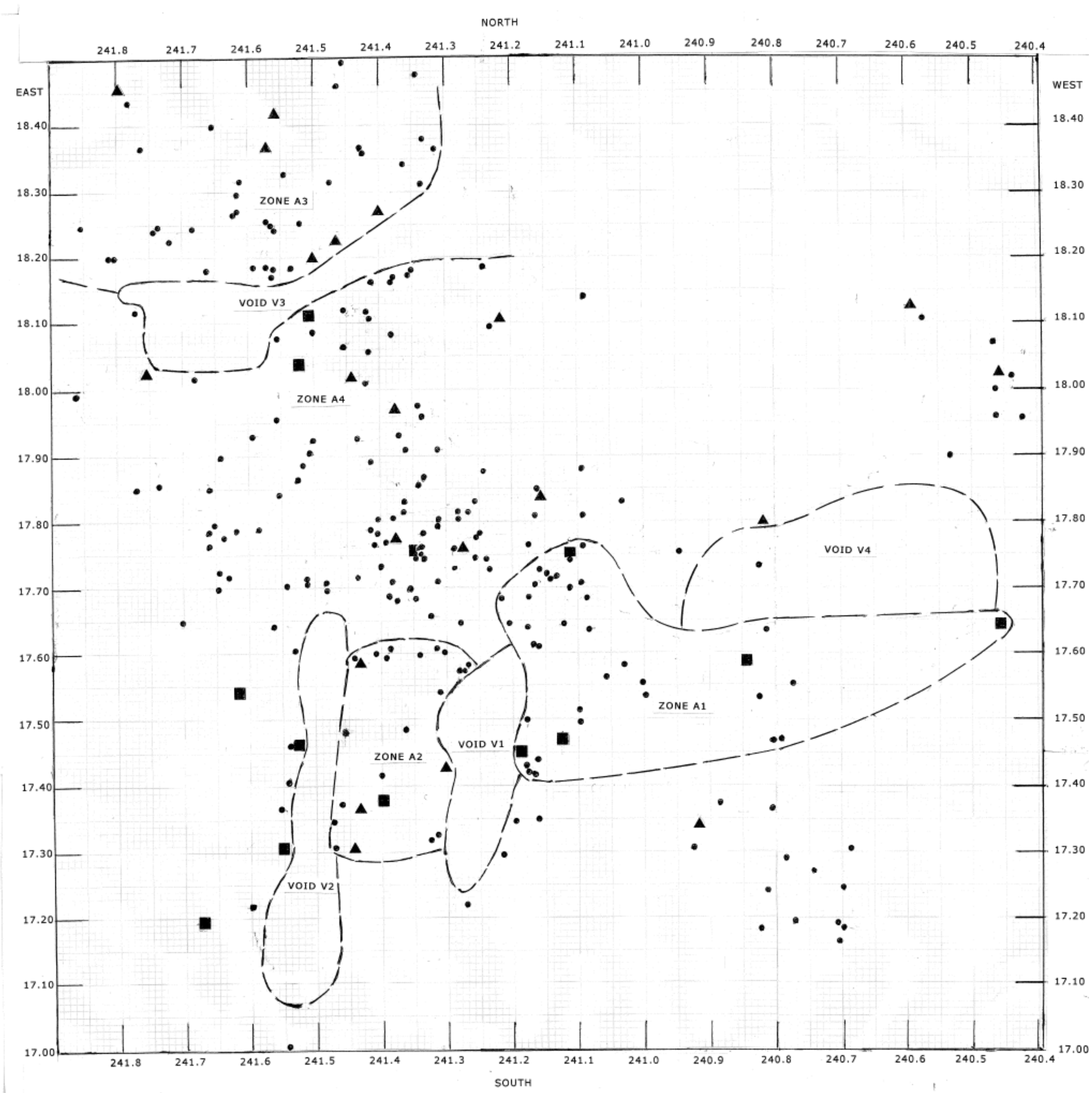
## 4. Results

251 galaxies were found of which 21 were clockwise spirals and 13 were anti-clockwise spirals, see the diagram. There appears to be a general rule that clockwise and anti-clockwise spirals are not intermingled. For example there is an area in the north east corner of the diagram where there are 6 clockwise spirals and no anti-clockwise ones. (This will be studied in more detail later). There are some apparent exceptions to this rule.

The first exception is the anti-clockwise galaxy at RA 241.3474 Dec 17.7572 which appears to be among a group of clockwise ones: 241.2829/17.7577 z = 0.03342 and 241.3776/17.7687 z = 0.03733. In reality this anti-clockwise galaxy has a redshift (z) of 0.03193.

On the general principle that larger redshifts indicate further distances from Earth, this anti-clockwise spiral is nearer to Earth than the clockwise ones. Therefore this apparent proximity is not real. Another exception is the anti-clockwise spiral at 241.3986/17.3759 which is near to a clockwise one. This anti-clockwise galaxy is faint and hazy; it is not a typical spiral galaxy.

Finally there are two anti-clockwise spirals at 241.5080/18.1125 and 241.5220/18.0364 which are fairly near the clockwise one, 241.4430/18.0168. What is more significant is that these two anti-clockwise spirals are near to each other and they are on the edge of a void, and this will be discussed below.




The Hercules Cluster of Galaxies

Key, ▲ clockwise spiral galaxies, ■ anti-clockwise spiral galaxies, • all other types of galaxy.

In the further discussion it will be shown that there are some zones where there are clockwise spirals – but anti-clockwise spirals are completely absent. Conversely there are two zones where there are anti-clockwise spirals - but clockwise ones are completely absent. Hence it is a *fair generalization to say that clockwise and anti-clockwise spiral galaxies are not randomly mixed*.

We now come to discuss the voids. All three Voids marked V1, V2 and V3 contain no galaxies, they are completely empty. The Void V4 contains only a single galaxy. The space to the west of V1 contains galaxies of which 5 are observed to be anti-clockwise; clockwise spirals appear to be completely absent. On the other hand, on the east side of V1 there is a clockwise spiral and no anti-clockwise ones. This is the first confirmation that spiral galaxies on the opposite sides of voids have opposite chirality. There was no “cherry picking” in this study, - that is to say, - galaxies were not chosen to support my theory, nor were galaxies deleted if they did not suit the theory.

The void V2 is fairly narrow but there are distinctly 3 clockwise spirals on the west side and 2 anti-clockwise spirals on the east side. Void V3 shows a clear line of 3 clockwise spirals on the north-east edge and there are 2 anti-clockwise ones on the south-west side. Void V4 has a single clockwise spiral on the north side and a single anti-clockwise one on the south side.

It is conceded that the weakness of this study is that the numbers of clockwise and anti-clockwise galaxies are few compared with the total number of galaxies in the cluster. A statistical analysis is revealing. Zone A1 is a small cluster which contains 37 galaxies. All these have been identified by the Galaxy Zoo team as either anti-clockwise, elliptical, edge-on or “uncertain”. Five of these are observed to be anti-clockwise spirals; NO clockwise spiral galaxies are observed.

The important question is – “Have no clockwise spirals been observed because there aren’t any, or is this a statistical quirk that the team has missed them?” We need to consider these alternatives. Overall studies have shown that there ought to be equal numbers of clockwise and anti-clockwise spirals (Land, K. et alia, 2008). Have some of the clockwise spirals been missed for good reasons, e.g. that they are edge-on or nearly edge-on?

Let us consider the hypothesis that Zone A1 actually contains 10 clockwise ones and 10 anti-clockwise ones out of the total of 37 galaxies. What is the chance that the observers find only 5 anti-clockwise spirals and NO clockwise ones? That is to say, what is the chance of the “missed clockwise case”? Statistical analysis shows that this case is one in 61 - in a nut-shell - the hypothesis that the Galaxy Zoo team have missed clockwise spirals is unlikely. It is much more likely that there are no clockwise spirals in Zone A1, - or very few.

The same analysis can be done on Zone A3 where there are 6 clockwise spirals and no anti-clockwise ones in a total of 41 galaxies. The spurious chance that there are anti-clockwise spirals “missed” by the Galaxy Zoo team is one in 184. A feature of the Galaxy Zoo project is that every galaxy image was studied by about 30 volunteers. It is extremely unlikely that a majority of those 30 volunteers would have consistently “missed” all the anti-clockwise spirals among the 41 galaxies in Zone A3 and yet found the clockwise spirals. Hence, the observational evidence is overwhelming that spiral galaxies of each orientation attract each other into clusters and that they repel the opposite type.

The number of clockwise spirals in Zone A2 is significant. Zones A1 and A2 are on opposite sides of Void V1. This is confirmation of the prediction that on opposite edges of voids, spiral galaxies will have opposite chirality. The case across Void V3 is more striking. On the north-east boundary of Void V3, 3 clockwise spirals are lined up and on the south-west boundary there are 2 anti-clockwise spirals. Again there is opposite chirality across a void. It is a reasonable deduction that other galaxies - besides spirals – generate magnetic fields by reason of orbiting hot stars, and that it is the mutual repulsion of these magnetic fields which creates voids.

There is further corroboration from Schneiter et alia (2010) who have studied the magnetic field direction in a galaxy and found that “the most probable direction of the ambient magnetic field is on average perpendicular to the galactic plane” – which is to be expected if the magnetic field is caused by orbiting stars with a positive electric charge, - because it is a characteristic of electrical coils that the magnetic field is perpendicular to the plane of the coil.

## 5. Conclusion

It was predicted that spiral galaxies separated by voids between clusters will be found to have opposite orientations. Although in this study, the available spiral galaxies are few (as was conceded above) they all display this predicted characteristic; the cumulative effect of four voids, *all of which have galaxies of opposite chirality on opposite sides*, makes the *success of the prediction compelling.*

The distribution of galaxies into clusters and voids is dominated by the chirality of the galaxies. *There is no requirement for a “missing mass” or “dark matter” to account for the distribution of galaxies*. This follows the conclusion in my first paper, - that the missing mass does not explain the orbital velocities of hot stars and lone brown dwarfs in the Milky Way.

## 6. Further Discussion I

The alignment of spiral galaxies and their orientation with respect to voids has been dealt with by other researchers. Here is a selection with brief quotations from the papers:

Slosar, A. (2006) “Galaxy Zoo: Chiral correlation function of galaxy spins”: “We measure the correlation function of spin chirality of face-on spiral galaxies in angular, real and projected spaces. Our results indicate a hint of positive correlation at separations less than ~ 0.5 Mpc.”

Trujillo, I. et alia, (2006) “Detection of the effect of Cosmological large scale structure on the orientation of galaxies”: “We show that these alignments do indeed exist: spiral galaxies located on the shells of the largest cosmic voids have rotation axes that lie preferentially on the void surface.”
Jones, B.J.T. et alia (2010) “Fossil evidence for spin alignment of Sloan Digital Sky Survey galaxies in filaments”: “We constructed a catalogue of clean filaments containing edge-on galaxies. Statistical analysis indicates that the distribution of orientation of these edge-on galaxies relative to their parent filament deviates significantly from what would be expected on the basis of a random distribution of orientations”.

Jimenez, R. et alia (2010) “Galaxy Zoo: a correlation between the coherence of galaxy spin chirality and the star formation efficiency”: “Our findings suggest that spiral galaxies, which formed the majority of their stars early ($z > 2$), tend to display coherent rotation over scales of ~10 $Mpch^{-1}$ . We find evidence for this alignment at more than the 5σ level, but no correlation with other galaxy stellar properties".

Although these papers anticipate the concept that there is "coherence of galaxy spin chirality" and that "spiral galaxies located on the shells of the largest cosmic voids have rotation axes that lie preferentially on the void surface", none of them actually *predicts* that the galaxy spin chiralities would be opposite each other across the space of voids.

The present theory encompasses features which other theories do not have:

(1) The velocities of electrons in hot stars are far greater than the velocity of escape and therefore these hot stars must be positively charged in order to hold back the electrons.
(2) The effect of this electric charge is sufficient to explain the so-called "flat rotation curves" in galaxies.
(3) Brown dwarfs, which are not hot, have orbital velocities below the flat rotation curve.
(4) The orbiting hot stars create a magnetic field.
(5) Spiral galaxies with the same chirality will attract each other and spiral galaxies with opposite chirality will repel each other. It is a reasonable corollary that other rotating galaxies will follow this rule. In this way clusters and voids are created.
(6) The positive electric charge on the Sun causes it to be an almost perfect sphere, contrary to the usual characteristic of rotating bodies. This was an unexpected bonus to the new theory.

Zwicky (1933) postulated that there needed to be a missing mass in order to hold clusters together gravitationally, and he wrote in 1937 - "This tendency of nebulae toward clustering is no doubt due to the action of gravitational forces." This belief in a missing mass has been held ever since.

It is here concluded that there is no necessity for a missing mass because magnetic forces can do the job of holding clusters together.

## 7. Discussion II

Received wisdom is that dark matter is some kind of particle, hitherto undiscovered. This raises some questions:
(a) How does a universally distributed dark matter create voids which are completely empty of galaxies?
(b) Why should dark matter cause a differentiation between clockwise and anti-clockwise galaxies as viewed from Earth?

Dark matter was discussed at a meeting in London in February 2006. Professor G. Gilmore made a presentation on the progress in research on dark matter (The Guardian, 6th February 2006). To quote, "[t]he biggest surprise is that dark matter is not cold cosmic sludge that scientists once thought. Its temperature is calculated to be tens of thousands of degrees, although this is not normal heat. Normal hot things glow and you can feel the infrared coming off. The strange thing about dark matter is that it doesn't give off radiation. This is because dark matter is not made of electrons and protons, the fundamental particles that everything else consists of. Whatever its mysteries, dark matter has its uses. It is essential in keeping the universe ordered and without it, the galaxies would quickly fall apart. The Sun is moving so fast that if it weren't for dark matter, it would fly straight off out of the Milky Way."

These features are dealt with here in turn:

(a) Galaxies do not "fall apart", because the hot stars are electrically positively charged and for the same reason the Sun would not "fly straight off out of the Milky Way". The explanation was covered in detail in my first paper.

(b) Temperature is a fundamental property which is measured by a thermometer. Degree Kelvin is one of the six fundamental units (Système International, SI). The energies of atoms and molecules conform to the Maxwell-Boltzmann equation. The thermometer bulb also conforms to the Maxwell-Boltzmann equation and temperature measurement involves the thermal equilibrium between matter and the thermometer bulb. This is what we mean by "measuring temperature". If dark matter does not relate with ordinary matter, - then referring to its temperature is meaningless.

(c) Considered strictly, temperature is measured by means of a Carnot Cycle, - and indeed, this is the way in which we measure temperatures below one degree Kelvin, - we put a paramagnetic salt through a Carnot Cycle.

But it can be shown by means of the Kelvin Theorem that a temperature measured by the ideal gas thermometer is identical with the Carnot Cycle, - if it were not so, large sections of Physics and Chemistry would be invalid!

The crucial question is – "Can dark matter be put through a Carnot Cycle conceptually?" In order to address this question, dark matter needs to have various properties such as specific heat capacity and the ability to exchange heat with a reservoir. If dark matter does not fit these criteria, these short-comings are a "fatal blow" to the idea that dark matter can have a temperature, - if indeed, - dark matter exists at all.

## 8. Future Work

The Milky Way and the Andromeda Galaxy are moving towards each other. The plane of the Andromeda Galaxy is at an angle to the plane of the Milky Way. Nevertheless, both of them generate a magnetic field. It will be of interest to see whether there is a partial alignment of these two magnetic fields. Pan et alia (2012) have set up a catalogue of a large number of voids based on SDSS, DR7. Some of these voids are simply "underdense regions". However if some true voids are identified and if associated galaxies are to be found in the Galaxy Zoo table, the new theory can be tested further.

## Appendix

The practicalities of this study are as follows. In the website of SDSS, DR7, two co-ordinates were selected (Right Ascension and Declination) and these were entered into the "computer fields" in the program of SDSS, DR7; click on "get image". If the computer screen displays a galaxy, this is pin-pointed by the cursor. The computer then displays the co-ordinates and magnitude values of the galaxy. The cursor is then clicked onto "quick look"; the program provides further data: the identification number, ObjID (18 digits), the galaxy co-ordinates to 7 decimal places, and the red-shift, z.

The researcher can now re-enter the galaxy co-ordinates more accurately into the display in order to obtain an improved image of the galaxy. Sometimes it is possible to identify whether the galaxy is a spiral, - clockwise or anti-clockwise. If this identification is not possible, the procedure is to search the Galaxy Zoo Table. The researcher applies the RA number and the ObjID number in the Galaxy Zoo Table. Each line defines a galaxy and there is a code number which states whether the galaxy is elliptical, clockwise, anti-clockwise, "edge on" or "uncertain". The positions of the clockwise and anti-clockwise spirals are recorded and plotted on the diagram. For the purposes of plotting these results, the "elliptical", "edge on galaxies" and "uncertain" are grouped together.

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Additional Information:

Galaxy Zoo Release, http://data.galaxyzoo.org

Sloan Digital Sky Survey, http://www.sdss.org and http://www.sdss.org/dr7

The Diagram, full size, 42 cm x 45 cm can be obtained from the author at £5.00 to cover printing and postage.