Is the periodic impact flux on Earth sensitive to whether the Milky Way is a grand design or Flocculent spiral galaxy?

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Abstract:
Impact Flux in this context simply refers to asteroids impacting celestial bodies. This paper looks at if the impact flux on Planet Earth and whether it is sensitive to the Milky-way galaxy being either a Grand Design spiral galaxy or a Flocculent Spiral Galaxy. This research is important in astrophysics as meteorite and asteroids can have a radioactive signature which can be tracked back through the asteroids trajectory, this can be useful in determining the structure of the Milky-way galaxy, as currently we some observational evidence of the milky-way suggesting it could be a Grand-design galaxy, however we are still unable to verify those observations, as we cannot currently confirm using the same process as we go through to look at other galaxies. This paper suggests that there is a potential link between the impact flux and Earth being sensitive to the structure of the Milky way, however more research is required to say for certain.

Keywords:
Flocculent Galaxy, Grand Design Spiral Galaxy, Milky-way Galaxy, Impact Flux

Introduction

The structure of the Milky-way galaxy is still unknown to us, this is after decades of research into the matter, and the technology to view distant galaxies this leads to the question of is the Milky-way a Grand design spiral galaxy or a Flocculent Spiral Galaxy? There is observational evidence which supports the claim that the Milky Way is a Grand design spiral galaxy. This then raises questions such as does the galaxy classification influence or affect the impact flux on the Earth?

Project Background

We have been able to see outside our galaxy for some time now, this is now done by having a high-powered telescope either on Earth or in space focused on very bright light sources in space. Because Galaxies are large enough and bright enough, we can see them within our own solar system. The question inevitably comes to can we see the Milky-Way and what does it [the Milky-Way] look like? Well unfortunately we cannot observe something that we inhabit we do not know conclusively, there is, however, some observational evidence that suggests that the Milky-way is a grand-design spiral galaxy. Impact Flux on Earth might be a solution to our problem of not being able to see the Milky way. Impact Flux simply is how many asteroids hit a body

in space. This might help us determine the Milky-Way structure as radioactive material can be deposited as the asteroid moves across space, almost like leaving bread crumbs in its path, if we are able track that radioactive material back, we could piece together the origin point of that asteroid, and if it started at the end of a spiral it could be evidence that the Milky-way is indeed a Grand-design spiral Galaxy.

Literature Review

Contents

Introduction

This literature review will review the difference between Grand-design spiral Galaxies [Figure 1] and Flocculent Spiral Galaxies [Figure 2], covering topics such as the appearance of each star using the Hubble classification system, star formation within each type of galaxy and the formation of the galaxies themselves.

Figure 1: An grand design galaxy.

Illustration of M100, a (Nasa/Esa

Paper 1: The near-infrared atlas of spiral galaxies.

The researchers had surveyed fifty-four galaxies that were fully observable in the hopes to determine the classification of each galaxy.

Figure 2: (Colombari, 2021). Massive Nearby Spiral Galaxy: NGC 2841

- Researchers found that the patchiness of Flocculent spiral galaxies could be down to having more regions of Hydrogen-2 around the Galaxies Halo (Elmegreen D. M., Nov. 1981).
- A limitation of this paper is that all the galaxies surveyed seemed to have two clear spirals either partially or fully developed, the issue is flocculent spiral galaxies tend not to have distinctive spirals.

Paper 2: Star Formation In Grand Design and Flocculent Spiral Galaxies

The formation of stars is an important part of a galaxy's life cycle, as such these researchers were investigating whether there is a difference between the formation of stars in Grand design galaxies and Flocculent spiral galaxies.

- The data suggested that grand design galaxies tend to "bluer" than Flocculent spiral galaxies by approximately 0.05 for all galaxies which would fall into the (B-V) category and by approximately 0.15 for all within the (U-V) category. (Romanishin, 1985)
- However, one limitation of this paper was that there wasn't any consideration for galaxy size or the bulge to disk ratio, which could affect star density.

Paper 3: A turbulent origin of flocculent spiral in galaxies

The formation of flocculent spiral and grand design galaxies are important as this helps guide its life cycle, which influences how they look, and the spirals move around the galactic core.

- The formation of Flocculent spiral galaxies is a result of large-scale gravitational instabilities which creates the patchy appearance of them. (Elmegreen, Elmegreen, & Leitner, 2003)
- A limitation of this paper is that it is based off the hierarchical structure of star formations, however within galaxies and clouds there wasn't any numerical solutions to the problem, which meant that the researchers had to solely base the paper off the numerical solutions for clouds, which are known.

Conclusion

Overall, Flocculent spiral galaxies and Grand design galaxies are very distinct, in most aspects. Which include:

- The average Grand design galaxy is a little bit bluer than the average Flocculent spiral galaxy, because of the star density in Grand design spiral galaxies.
- Flocculent Spiral galaxies contain more hydrogen-2 molecules than grand design spiral galaxies in their halos.

- Flocculent Spiral Galaxies have a much more turbulent and intense formation process than Grand design spiral galaxies have, causing their patchy appearance.

Methodology

The research carried out was by conducting a Literature review, this was the most sensible way to organise and collect the data as it allows a clear contrast between the two different galaxy structures. Then with this data I was able to categorise different galaxies into two different sections: Grand design spiral galaxies, Flocculent spiral Galaxies. The galaxies were separated based on the factors included within the Literature review, which are as follows; classification of infrared emission, the formation of star within the galaxy, and how turbulent the formation of the galaxy was. I also have included an example of a grand design spiral galaxy and a flocculent spiral galaxy within an academic poster.

Results

Examples of Grand Design Galaxy	Examples of Flocculent Spiral Galaxies
M100 *(Schmidt, J. 2017)*	NGC 2841(Nasa, 2011)
NGC 5055 (Sarkar, Narayanan, Banerjee, & Prakash, 2023)	NGC4496A (Sarkar, Narayanan, Banerjee, & Prakash, 2023)

It is worth mentioning, especially as this is an important part of this project, that I haven't included the Milky-way Galaxy within either category, this is simply down to the uncertainty in which we have very little detail to which category the Milky-way Galaxy falls under. However, it is also important to mention that there is observational evidence which suggests that the Milky-way galaxy is a grand design spiral galaxy, but as we inhabit the Milky-way galaxy getting a clear image of it, does make it hard for us to concretely say whether the Milky-way is a grand design spiral galaxy.

Newly classified Grand Design galaxies and Flocculent galaxies have spiral that travel with velocities with a mean value of $218 \pm 86\ km^{-1}$ and $146 \pm 67 kms^{-1}$ respectively (Sarkar, Narayanan, Banerjee, & Prakash, 2023) this suggests that galaxies that fall into these categories has a similar spiral rotational velocity as these newly classified galaxies. It is also important to note that Grand design galaxies and Flocculent spiral galaxies have unique spiral orbital patterns depending on which classification a galaxy fall under but can also be influenced by

other factors such as size of galactic core. This suggests that there is a distinct possibility that impact flux can and is influenced by the classification of galaxy whether they be Grand design spiral or Flocculent spiral galaxies.

UROS Experience

My experience with participating in the undergraduate research opportunities scheme (UROS) has been amazing. Since starting this scheme, I have developed a keen sense of understanding to what it means to be a scientist, a physicist. I have been able to engage with the topic of astrophysics in a way that, I suspect, I would not have been able to otherwise, as this has allowed me the freedom to explore many aspects of a fascinating topic, that is galaxies and their structures and given me full command of what I put into my literature review and research while still having a precise goal. This freedom that I've had with this scheme I've found to be very important, because it made me want to improve my entire research at every point, as this is my work that I wanted to do, rather than some copied and pasted assignments that a lecturer has been using for the last few years. The discovery of the unknown is a driving force in all of science, no matter of the field, and because of this scheme I have had a taste of what that's like, as before this I had no idea the complexities of galaxies and galactic bodies, that they can take different shapes and sizes the implication of them. But now I am probably more interested in astrophysics and the structure of galaxies that I have ever been.

Conclusion

As discussed before, the impact flux is likely influenced by the structure of galaxy, because of the spiral velocities as well as their unique rotational orbit within the galaxy. Under the assumption that impact flux is evenly distributed across the galaxy, the impact flux on Earth would be sensitive to the structure of the Milky-way galaxy. However, this is just an assumption, a way this could be tested, practically, would be through computer simulations of Earth in model Grand design spiral galaxies and model Flocculent spiral galaxies, using a few known galaxies of each category to increase the reliability of the results, as well as potentially being able to gain an insight into the true structure of the Milky Way as Earth should follow a similar rotation in a galaxy with a similar structure to the Milky-way.

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