

Project Activity Log

Learner Name: _____ Learner number ____

Centre Name: _____ Centre number ____

Unit Name: _____ Unit number ____ Unit 2 ____

_____ P301 _____

Teacher Assessor: _____

Proposed project title: ____ How does the Rotational Velocity of the Milky Way Galaxy at Different Radii Correlate to its Expected Mass Distribution? _____

This form should be used to record the process of your project and be submitted as evidence with the final piece of work.

You may want to discuss:

- what you have done (eg, from one week to the next)
- if you are working in a group, what discussions you have had
- any changes that you have or will need to make to your plans
- what resources you have found or hope to find
- what problems you are encountering and how you are solving them
- what you are going to do next

Date	Comments
29/09/2022	<p>Today, we had our first Project Preparation lesson for EPQ. We were instructed to bring a non-fiction text to class, and I brought my copy of <i>Light in the Darkness</i> by Heino Falcke. This book is about the Event Horizon Telescope, and how they photographed the M87 black hole successfully in March 2021.</p> <p>I want my project to be about an astronomy-related topic, because this is what I want to study at university, and we don't get the chance in AS level to explore this topic. I learned the difference between a dissertation and an investigation, and I would like to attempt an investigation, although it might be difficult to find the appropriate astronomy topic.</p>
8/10/2022	<p>Today we first discussed the activity log, and project organization. I've been revisiting my notes from some astrophysics lectures I attended last summer, and I'm particularly interested in exoplanets.</p>

14/11/2022	<p>I'm currently struggling to choose a project title. There are so many topics I find interesting about astronomy, and it's been difficult to put my thoughts in order. I would like to carry out an investigation, but astronomy instruments are typically university-grade, and thus will remain inaccessible to me. I am still interested in collecting my own data, if possible, so I will continue to look into my options.</p> <p>As an alternative, I could write a dissertation. I have some project ideas, primarily about exoplanets and dark matter, but I'll continue brainstorming in the coming weeks.</p>
23/11/2022	<p>Today I wrote a list of 12 dissertation ideas and ranked them on feasibility and my enthusiasm. My top candidates right now are</p> <ol style="list-style-type: none"> 1. The history of the search for Dark matter (analyzing different possibilities) 2. Space telescopes vs ground telescopes, James Webb and the future of telescopes 3. The search for extraterrestrial life and its future 4. Large-scale interferometry and the Event Horizon Telescope 5. Atmospheric analysis of newly discovered exoplanets <p>I scheduled a meeting with my mentor, _____ for tomorrow, to discuss my project ideas.</p>
24/11/2022	<p>I met with _____ today, and he approved of my topics. However, he suggested that I could still write an investigation, if I collected data from secondary sources (online databases.)</p> <p>This gave me a lot to think about. I've primarily been interested in two fields of astronomy in the past few weeks: cosmology and Helio physics, and perhaps I could use solar data or redshift data for my project, especially with the newly launched James Webb telescope and Parker Solar Probe missions.</p>
1/12/2022 - 16/01/2023	<p>During this time I didn't work on the EPQ as much, as I focused on the mock exams and my upcoming January exams. I've been reading some astronomy material and I'm thinking of what type of data I'd like to analyze. I find that the solar databases are a less feasible option, as the data is very difficult to analyze using my high school physics knowledge.</p>
17/01/2023	<p>Now that I've taken all my January session exams, I've started thinking about my project proposal again. I met with _____ and we discussed the possibility of doing a project related to cosmology or dark matter. I have a great interest in cosmology, and the study of galaxies, and I think I can research something related to the motion of galaxies or perhaps the expansion of the universe.</p>
20/01/2023	<p>Today I submitted my project proposal. I've decided to study the rotation of galaxies using radio signal intensity measurements, and to suggest whether or not my results could be affected by dark matter. This is a very interesting topic to me, about which I know only a little, and I'm looking forward to starting the project.</p> <p>The investigation would involve collecting data from online databases, as discussed with my mentor, as I don't have access to any observatories or radio telescopes. I really want to try and collect some of my own data, but for now I will mainly look for online data. The SPARC database seems to be a promising source.</p>
31/01/2023	<p>This week, I wrote the first 500 words of my literature review about Doppler spectroscopy. This was my first writing exercise. I read about the methods astronomers use to measure velocities in space. Spectral lines of emission, which we are also studying in AS Physics this year, are observed for any frequency shifts, which can indicate that the source is in motion. This will be an integral part of my</p>
21/02/2023	<p>In the past three weeks, I started researching the 21-cm hydrogen line, and its applications to radio astrophysics. I hope to find some data regarding this line.</p>

6/03/2023	<p>Today I finished reading the Queen Mary University textbook on Galaxies. (Jones & Saha, 2007). This has been a great source allowing me to understand galactic dynamics. Although, because it's a university textbook, there are some concepts that aren't immediately explained to my level of understanding, and I'll have to do some additional research to fully grasp them.</p>
27/03/2023	<p>The past week has been incredibly stressful, as several mock exams have been lined up during a couple of days, and head student applications are due this week.</p> <p>I'm having some difficulty finding reliable sources that I can cite, and it's been hard to find material on the history of many of these discoveries. I think I will finish the literature review. I am also slightly worried about creating an overlap between my experimental methods / analysis section and the research review, so I am avoiding writing too much about the Doppler effect and what formulas I have to use.</p> <p>There seems to be a general consensus in scientific literature that rotation curves don't the Keplerian prediction. I was already familiar with the concept of dark matter before this project, but I've learned so much about the various models and theories that have been put in place to explain the unusual rotation curves.</p>
31/03/2023	<p>I've encountered a lot of obstacles during this research review, as a lot of the material about radio astronomy and rotation curves is very advanced, typically undergraduate material and sometimes even graduate papers. There are a lot of prerequisite math concepts that I don't fully grasp yet, and that are taught in university.</p> <p>However, I was able to write 1600 words for my research review, and I'm very pleased with the result. Most of the review focuses on the history and application of spectroscopy as an observational field in astronomy, as well as the scientific consensus surrounding flat rotation curves. I've learned so many new concepts and I'm even more excited to continue the project.</p> <p>I still have some concerns regarding overlap with the methods section, which I communicated to _____, and I think we will discuss that during next week's lesson.</p>
4/04/2023	<p>I had some time this weekend to research some data sources. I also found some useful articles detailing the experimental methods used in recent history, which I could adapt for my investigation. I was looking across researchgate.net to find data, and I came across a 10-page argument on a Q&A forum...</p> <p>Today's EPQ lesson came as quite a shock. We covered some specifications for each project type, as most of my class completed their research reviews, so we were ready to begin writing on the next section. The specification meant for investigations stated that primary sources and personal data collection are a key component of the project.</p> <p>I am very worried, as there is no way for me to collect data myself. Most radio telescopes are huge ground-based antennas which are only accessible to research institutions, and I certainly can't access a space telescope either. I don't think that any radio telescopes even exist in Romania. I am setting up a meeting tomorrow with my mentor _____, to discuss what I can do in this situation. I am seriously considering changing my project to a dissertation about the same topic, if I can't investigate it.</p>
5/04/2023	<p>Today I met with _____, to discuss whether I can still use secondary data. He showed me a contradicting document which does suggest that it's possible. He said that he will also contact the exam board about it. This is good news, but it's not definitive, so I'm putting off methods research and instead reading more into dark matter for now. I find this subject so interesting, researchers propose that there may be a dark matter halo surrounding our galaxy.</p>
22/04/2023	<p>This week I received great news, that my initial plan of using publicly available research data is still viable. _____ said that the exam board confirmed it's allowed for an investigation,</p> <p>I enrolled in an astrophysics research camp at the Pisgah Astronomical Research Institute, in North Carolina, with a focus on Milky Way radio observation. The topics covered will include the structure of the Galaxy and how radio telescopes work. I will be attending camp in late July, and I will be able to carry out some research using the radio telescopes, and I expect a</p>

	<p>lot of insight into radio observation methods and what type of data I need. I may even be able to get most of the data for my investigation, shifting my sources towards primary/first-hand observation.</p>
10/05/2023 - 10/07/2023	<p>In the past 2 months, there was not much work done on the project, as I was busy with revision, preparing for the May-June exam sessions, and volunteering after exams had ended.</p>
10/07/2023	<p>I'm leaving in a couple of days. I don't think I'll have sufficient time until then to select and analyze data. I look forward to discussing with radio astronomers at camp and getting some very useful insight and a primary information source. This will allow me to develop an improved experimental method.</p> <p>I think it's best that I continue working once I return, as I'll have a better understanding of my topic.</p>
31/07/2023	<p>The camp is over! I've learned so much, particularly about the Milky Way and interstellar hydrogen gas. We also covered satellite telecommunications. There were several lectures on radio telescopes and I'm much more confident in my knowledge now. During the camp, I carried out a team research project mapping the Milky Way, and I had several hours of experience controlling a 12-meter radio telescope and collecting data.</p> <p>Also, I received a login to access the internet-controlled interface of this telescope, and I will be able to collect my own data for EPQ after all!</p> <p>I've scheduled several observation sessions for next week.</p>
6/08/2023	<p>Unfortunately, the radio telescope has been down for two days due to weather conditions. There is a series of thunderstorms affecting the eastern US and the PARI staff shut the telescope's servos off until weather has cleared.</p> <p>I will have to reschedule my observation sessions after the weather system has moved out of the way. In the meantime, I started writing my Instrumentation and Methods section. I wrote about PARI and the 12-meter telescope, and the coordinate systems that I'll have to refer to during my observations. I've truly realized how complex the project really is, and I might be going over the word count, but I'm very excited to collect my own actual data. I never thought this would be possible, and it feels like I'm contributing in some way to scientific research, which is amazing.</p>
12/08/2023	<p>The field studies officer at PARI emailed me back and said that the telescope should be operational now. I have scheduled my first session for tonight, and I expect I'll collect all of my data by the 15th.</p> <p>Unfortunately, the part of the Milky Way that I need to observe is above the horizon only between 3:00 and 6:00 AM, so I will have to either stay up until that time, or wake up extremely early. I think I'll do the latter, and continue writing after each observation session.</p> <p>I expect it should take about two or three days to get all of the observations in.</p>
14/08/2023	<p>As of today I've finished all the required observations. I started inspecting and analyzing my data, and I grouped every quantity into the Microsoft Excel spreadsheet. One feature I noticed is that the observed signals for $18 < l < 34$ begin outside the observed range. I would like to repeat the observations for those points, with a greater range, so I can ensure my data is accurate. I finished writing about the Doppler formula, and its non-relativistic approximation. I currently have 4,500 words. My next, and final observation session is on the 16th at 5:45 AM.</p> <p>I've also been researching how to correct for the Sun's peculiar motion, and Earth's rotation and revolution, which affect my results. This took me a while to understand, as it's very complicated and has some aspects that are not fully understood yet, like the exact location of the dynamical center of the galaxy. However, I was able to read about the formulae and</p>

	<p>coordinate conversions involved, and I found an excellent NRAO (National Radio Astronomy Observatory) resource that can perform those calculations for me.</p>
16/08/2023	<p>The observation session was a success and I have all the data I need to finish my project. I started organizing my spreadsheet and making the first $V(R)$ graph (rotation curve). This is a big part of my final project outcome, and I'm starting the final writing stages of my project.</p> <p>I made several diagrams to better represent my data using Google Docs Drawings.</p>
21/08/2023	<p>In the past few days, I finished the Experimental Methods section and the Data Analysis section, where I discussed and explained the data collection parameters and any uncertainties stemming from the observation process.</p> <p>I've already begun the Interpretation section, and I'm currently writing about how my results compare to the Keplerian hypothesis. The document is 6,000 words long already, so I am becoming increasingly conservative of what I will include. I am aware that the project will likely exceed the word limit by quite a lot, but it is necessary to include all the information I've had to learn and use throughout the investigation, and more importantly to make it clear for the reader too. One of the main issues I faced during my research phase was not understanding some of the university-level material, because a lot of background knowledge was assumed. Therefore, I documented and explained every important step of my process, and all the research and background information required to understand the investigation.</p> <p>I started writing my bibliography, using the Harvard referencing style. I encountered some obstacles when finding images that I can properly attribute to an author, and Wikimedia Commons has proven to be a valuable source of freely licensed material. I've credited the authors of all figures already, and I plan to finish the full project in the coming week.</p>
26/08/2023	<p>There was an incident where my computer restarted itself during the night, and some of my unsaved changes and opened research tabs were closed. I spent about an hour restoring everything and fortunately I'm back on track.</p>
28/08/2023	<p>This week has been extremely intense. I've been very motivated throughout and was able to complete my analysis and produce a result for the rotation curve. In concordance with related studies, but very unlike the Keplerian hypothesis, my rotation curve flattens out after 4 kpc!</p> <p>I decided on Tuesday that I would rewrite some portions of my literature review, as it was written with a different, less complete understanding of my experimental method. After researching constantly for the past three weeks, I concluded that a lot of what I wrote back in March no longer fits the structure and procedure of my investigation, and I rewrote 2,500 words covering all of the background information to my method and also mentioned the findings of other related studies. I removed the previous research review content to reduce my word count.</p> <p>I also took a great deal of time to create tables, graphs and illustrations for my project, mainly using Google Docs drawings and Excel. While writing about Newton's derivation of his law of gravitation, I was frustrated by the limitations of Google Documents' equation formatting, so I learned how to use the LaTeX programming language, allowing me to create higher-resolution formulas.</p> <p>Furthermore, I also completed the introduction, conclusion, discussion, and the last parts of the analysis section. I've reached a milestone of 8,500 words, but there are important elements left to explain and introduce, such as the methods used to determine Galactic Constants.</p>

31/08/2023	I've completed the writing part and my bibliography format. I also added a table of contents and changed my font size to Times New Roman 11 with 1.75 spacing. Hopefully this should allow my text to be more readable. I also started working on my presentation, I plan to structure it in a similar manner to my EPQ investigation, with an introduction and then my method and results, but I will also include a reflection on my project journey and explain my motivations in choosing the project question.
20/09/2023	Today I had a meeting with _____, and he handed me some feedback for my first draft. I later made some corrections to the in-text citation layout, made some figures larger for improved readability, and modified the conclusion to reduce repetition. I am also preparing for my presentation on Friday. I've finished most of the slides and am beginning to add transitions and themes. I also included more images.
22/09/2023	Today was my presentation day. I presented my project to 4 of my teachers and our Head of Secondary. Due to time constraints, I couldn't thoroughly explain each step of my process, but I managed to cover all the key points and presented my full project journey. However, I was quite glad that I didn't just read off the slides, and I was able to talk about the project journey. I am going to finalize this activity log and the final draft next week.
1/10/2023	<p>This is the final entry in the activity log, as my document and presentation are ready for submission. Upon reflection, I think this was probably one of my most difficult academic accomplishments. I've been able to learn so much about galaxies, astronomical observation in non-visible light and dark matter, and I think this knowledge could help me a lot as I move on to university. Furthermore, this investigation has been my first significant research experience and I've grown to be more familiar with academic reading, formatting and referencing.</p> <p>When I first started the project a year ago, I barely had any idea just how much work it would require, but I also didn't expect to enjoy it so much. I am very happy that I was able to collect my own data rather than use secondary sources, and I am very happy with how the project evolved over time, to something much more than I expected from the EPQ investigation.</p>