SM\_assessment

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| Principles | Template Prompts and Follow-Up Prompts |
| Elenchus  [Argo: Selected Principle(s):]  → Definition  [Argo: Selected Principle(s):]  → Recollection    [Argo: Selected Principle(s):]  → Induction | **Prompt**: “In which ways can Beyond the Standard Model searches be included in analyses to achieve a 3D imaging of the proton?  **Follow-Up 1**: “How do we define the current limitations of the Standard Model in terms of proton imaging, and in what ways might BSM searches offer complementary perspectives or solutions?  **Follow-Up 2**: “Are there any inconsistencies or unexplained phenomena in current proton imaging experiments that suggest the need for BSM explanations, and how have past discoveries informed our approach to these challenges?  **Follow-Up 3**: “How have past discoveries, such as the quark model, informed our current methodologies in probing proton structure, and what lessons can we apply to BSM searches?” |

1. Motivation of the Problem

**Why is this problem important in chemistry/materials science (or physics)?**  
This problem is important in physics because we know there is physics beyond the current theory (the Standard Model). My prompt focuses on how we can incorporate this “beyond the Standard Model” (BSM) physics into three-dimensional imaging of the proton. Currently, efforts to go beyond the Standard Model in proton imaging have mostly been done in one dimension using objects called Parton Distribution Functions (PDFs). Moving to three-dimensional (3D) imaging is a completely new field for physics and is very important because additional dimensions can capture more nuanced physics of the proton’s internal structure.

When you only have one dimension, you can only see a limited view of the proton. The real challenge now is to move into 3D imaging—particularly in momentum space—where distributions can be defined. It’s also known that full proton structure information might require five dimensions (two for position, two for momentum, and one for the fraction of the proton’s energy carried by a given parton). This is extremely difficult to achieve experimentally and theoretically, making the problem both cutting-edge and challenging.

**What challenges exist in solving this problem using traditional LLM approaches?**  
Since this problem is so extensive, typical Large Language Models (LLMs) often provide very general responses when asked about integrating BSM physics into 3D imaging of the proton. I haven’t yet found an LLM that can systematically guide the questioning or reasoning process in a structured way.

**How could a structured Socratic approach improve reasoning and outcomes?**  
A Socratic (or “guided question”) approach can help refine and define the problem more precisely. In science, defining a question well is often half the work. A structured Socratic approach can guide the conversation toward clearer research directions. For instance, asking a series of well-structured follow-up questions can prompt the LLM (or any collaborator) to provide more specific insights, methods, or theoretical frameworks relevant to discovering BSM physics in proton imaging.

2. The Mixed Socratic Prompt Method Used

I used a sequence of Socratic principles—starting with **Elenchus**, then proceeding to **Definition, Recollection and Induction** —because these prompts emerged from the model’s suggestions. Each step guided the LLM to clarify specific parts of the problem. I found these questions well-aligned with the direction I wanted to explore.

3. What Are the Prompts Used?

**Initial User Input (Problem Statement):**  
In which ways can Beyond the Standard Model searches be included in analyses to achieve a 3D imaging of the proton?

**System Reformulation into Socratic Prompts**  
Socratic Reformulation: How can Beyond the Standard Model (BSM) searches contribute to the development of a three-dimensional imaging of the proton, and what hypotheses might we test to integrate these approaches effectively?

4. What Are the Outcomes of This Example?

**How did the LLM refine its answers over iterations?**  
Over multiple iterations, the LLM provided increasingly specific information about 3D proton imaging and BSM physics. It began referencing quarks inside the proton and even historical examples—like how quarks were initially just a mathematical model before being experimentally validated.

**What key insights or discoveries emerged?**

The LLM offered some historical perspective on quark discovery, which parallels the current search for BSM effects.

**Any unexpected results or challenges?**  
No dramatic new insights emerged, but the structured approach did bring clarity to the question and context. It also confirmed that the LLM can highlight relevant examples and historical analogies, which can be helpful in guiding further research or discussion.

5. Comparison to a Non-Socratic Approach

**How did reasoning depth, self-correction, and hypothesis refinement compare?**  
Without the Socratic prompts, the LLM tended to give a broad, generic overview. It did not dive into the specifics of BSM physics or 3D imaging challenges.

**Would a traditional direct-answer prompt have produced different results?**  
Yes, in fact I tried a direct prompt without any Socratic structure. The response was much more general -- mentioning a list of potential fields and theories without providing practical suggestions on how to implement BSM considerations into 3D imaging of the proton.

**Did the Socratic method improve clarity, adaptability, or accuracy?**  
Yes, it improved clarity of the question itself. It also helped place the question into a more precise context—both historically and conceptually. Although it did not produce exact mathematical formulas (which was not expected from a general prompt), it did demonstrate better adaptability in guiding the conversation toward the core issues.