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Finding the Parameter Range in Gyrokinetic Simulation Database Generation using LLM

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In gyrokinetic simulations, accurate parameter range determination is critical for modeling and analysis. Traditionally, this involves extensive literature reviews and expert input, which are time-consuming and prone to human error. We propose using a Large Language Model (LLM) with Retrieval-Augmented Generation (RAG) to automate this process, thereby improving efficiency and accuracy in generating surrogate model databases for plasma simulations.

Gyrokinetic simulations play a vital role in plasma physics, helping to understand turbulence and transport phenomena. Critical parameters like temperature gradients, density gradients, and magnetic field strengths must be accurately identified for these simulations to be practical. Conventional methods for determining these ranges are labor-intensive and depend heavily on expert knowledge, leading to inconsistencies.

Our approach leverages an LLM with RAG to automate parameter range identification. We collect and preprocess data from existing literature and simulation databases, feeding it into the LLM, and train it to recognize patterns and extract relevant information. The RAG mechanism enhances the LLM's performance by retrieving pertinent data from external sources, producing more accurate and contextually relevant outputs.

The results demonstrate significant improvements in accuracy and efficiency. The automated process reduces manual effort and enhances the overall performance of plasma simulations. This approach shows promise for practical applications, offering a valuable tool for researchers in plasma physics. This research is supported by the National Research Foundation, Singapore.

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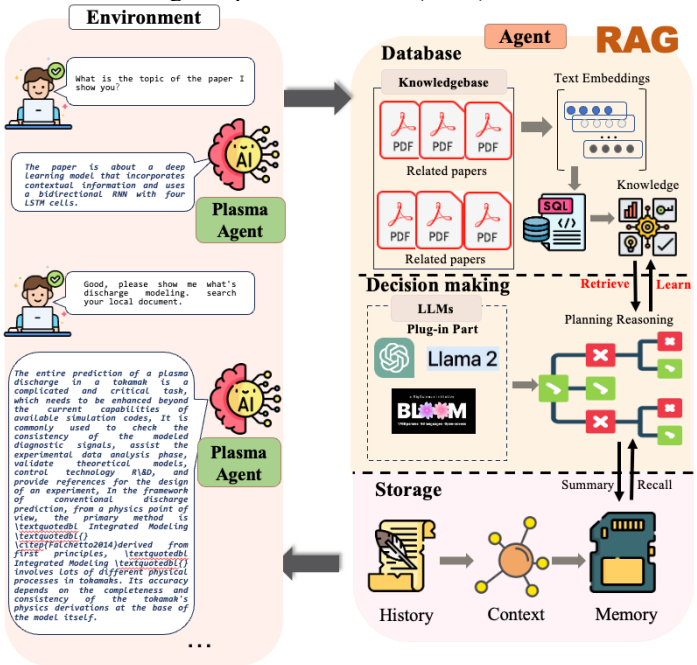

Figure 1. The framework of our plasma agent. The Agent units with LLM and RAG modules are the central processors, handling essential tasks such as memory retention, retrieval processing, and decision-making.