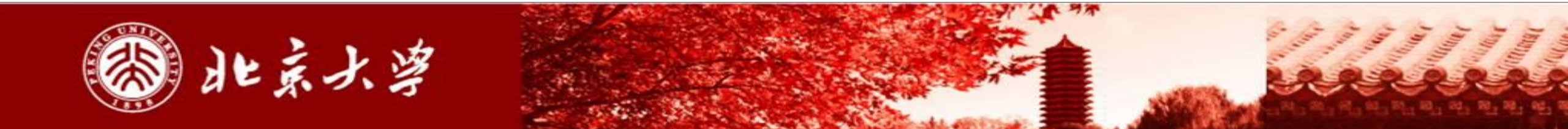
《物理与人工智能》

3. 大语言模型应用入门

授课教师：马滟青

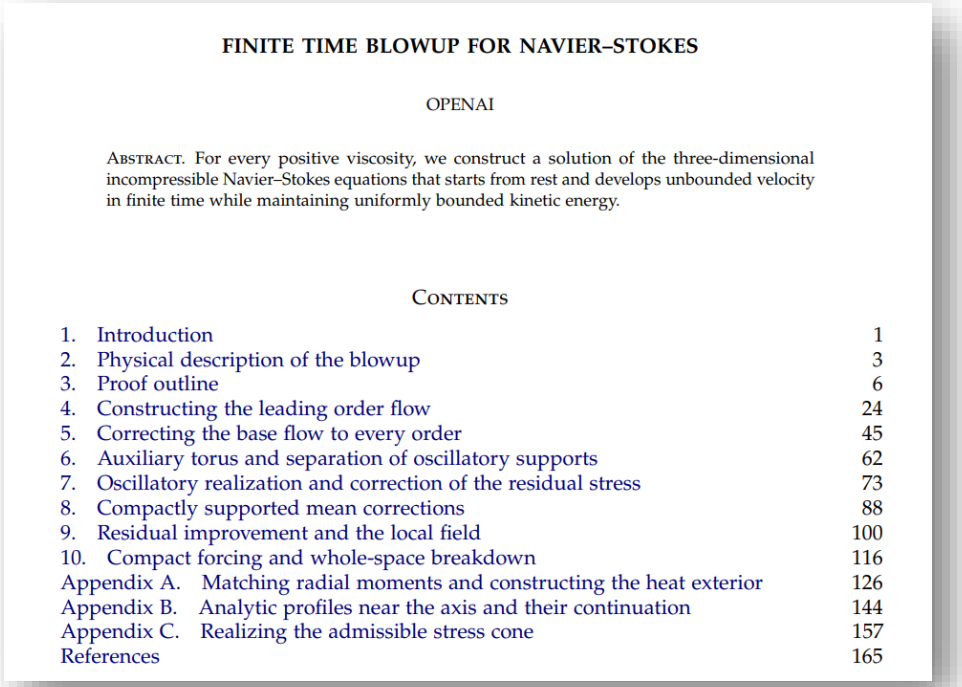
2026/09/14（第二周）



千禧年大奖被攻破

2026年9 月 8 日，OpenAI 公布165 页的数学论文，宣布找到纳维－斯托克斯方程存在性与光滑性问题的解答。

结论：对于任意正黏性，都可以构造一团从静止开始运动的三维不可压缩流体，在光滑外力作用下，让局部速度在有限时间内变得无界，同时保持总动能有界。这意味着，即使初始状态和外力都足够平滑，黏性也未必能够阻止经典光滑解发生“爆破”



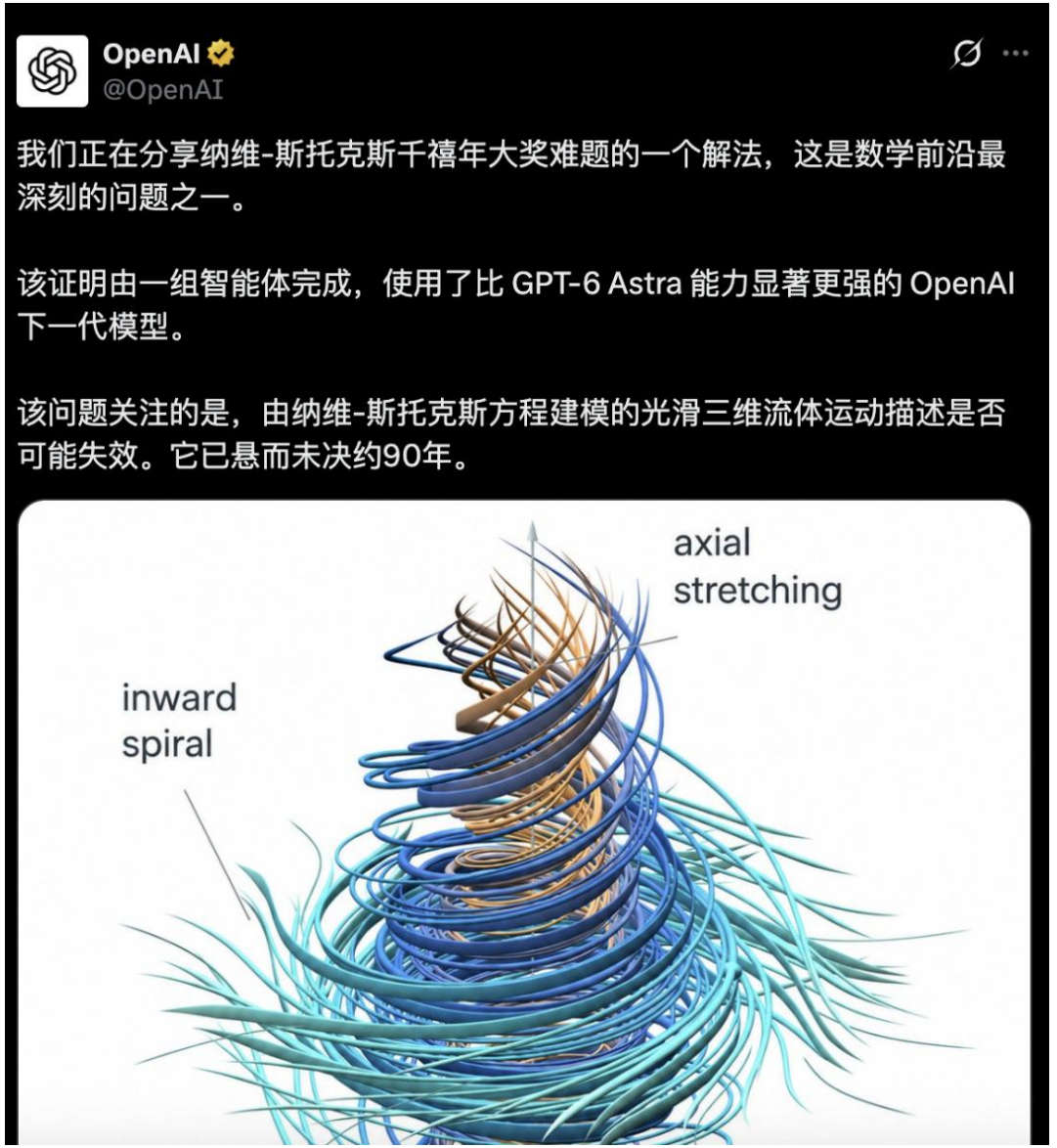
FINITE TIME BLOWUP FOR NAVIER–STOKES

OPENAI

ABSTRACT. For every positive viscosity, we construct a solution of the three-dimensional incompressible Navier–Stokes equations that starts from rest and develops unbounded velocity in finite time while maintaining uniformly bounded kinetic energy.

CONTENTS

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2. Physical description of the blowup 3
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“数学基因组计划”

2026 年 9 月 5 日，斯坦福大学数学系助理教授**Jared Duker Lichtman:** 打算联合学术界、前沿实验室、慈善组织和联邦政府，在资金与算力/tokens充足的前提下，用一年时间把全部已知人类数学形式化为机器可验证的代码，做成“数学版人类基因组计划”或“AlphaFold”式的工程；目前自动形式化代码约1300万行，已比18个月前提升5个数量级，而他们下一步希望在18个月内再提升5个数量级，达到约1万亿行。

Jared Duker Lichtman @jdlichtman · 9月4日

For those keeping score, 13M lines of code represents a 5-order-of-magnitude leap in autoformalized code from 18 months ago.

In the next 18 months, imagine generating the next 5-orders-of-magnitude: 1T lines of code.

19:12 · 2026年9月5日 · **103.7万** Views

Jared Duker Lichtman
@jdlichtman

We are now poised to:
Formalize all known Human Mathematics.

This is the modern equivalent of the Human Genome Project. or AlphaFold more recently, whereby all data of its kind is fully classified.

With sufficient funding and compute/tokens, a coordinated effort among academia, frontier labs, philanthropic organizations, and the federal government can formalize all Human Mathematics in the next year.



数学期刊的转化

Journal of AI-Assisted Mathematics



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物理何时被破？什么形式？

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翻译、数学：连根拔起

结束的开始: 2022 2023 2024 2025

- Chat client
- Translation
- Coding
- Mathematics

CHERRY STUDIO

DeepL

Cline

Google AlphaEvolve

NextChat



Claude

MadEvolve

MAGELLAN

Chatbox

GEMINI

Cici

GitHub Copilot

SkyDiscover

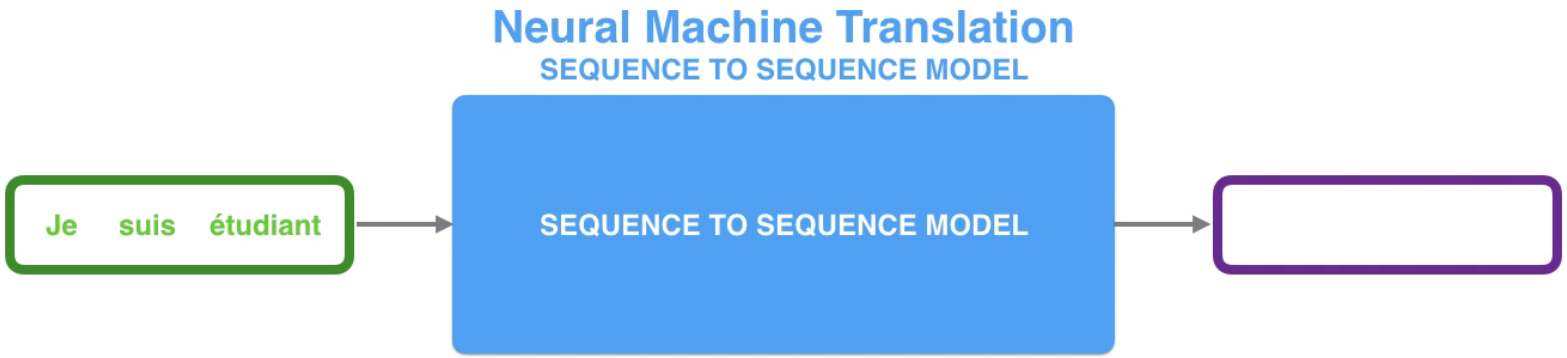
语言文学、代码：吃掉中低端

目录

- LLM调用及简单使用
- Agent及agent工作流
- 通用Agent及使用

大语言模型作为智能函数

$$y = f_{LLM}(x)$$



- 一次输入 ⇒ 一次输出
- 下次输入，全新输出

如何实现追问?

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请简洁回答：当前最强的大模型有哪些?

当前公认的第一梯队大模型主要有：

- **GPT-5.5 / OpenAI**：综合能力领先，推理、编程、多模态均衡。
- **Claude 4.5 / Anthropic**：长文本、编程、安全对齐突出。
- **Gemini 3 / Google**：多模态和超长上下文强。
- **Grok 4 / xAI**：推理和实时信息整合有优势。
- **DeepSeek-V3/R1 系列**：开源/高性价比代表，推理和中文强。
- **Qwen 3 / 阿里**：开源生态活跃，中文和多语言表现好。
- **Llama 4 / Meta**：开源权重模型代表。

如果只看"最强"，通常认为是 **GPT-5.5、Claude 4.5、Gemini 3** 三家领跑；开源阵营里 **DeepSeek、Qwen、Llama** 最常被提及。

这些最先进模型采用的什么架构

这些最先进模型基本都采用 **Decoder-only Transformer** 架构，但各自做了关键改进：

- **GPT-5.5 / OpenAI**：Decoder-only Transformer，推测使用 **MoE（混合专家）** 稀疏激活，配合大规模强化学习与推理时计算扩展。
- **Claude 4.5 / Anthropic**：Decoder-only Transformer，强调 **长上下文注意力优化** 与安全对齐训练，具体结构未完全公开。
- **Gemini 3 / Google**：**原生多模态 Transformer**，从训练初期就融合文本、图像、音频、视频，可能结合 MoE。
- **Grok 4 / xAI**：Decoder-only Transformer + MoE，强化推理与实时数据接入。
- **DeepSeek-V3/R1**：**MoE Transformer**，V3 用多头潜在注意力（MLA）和 DeepSeekMoE，R1 侧重强化学习推理。
- **Qwen 3 / 阿里**：**MoE Transformer**，部分版本支持多模态，注意力与位置编码有优化。
- **Llama 4 / Meta**：**MoE Transformer**，原生多模态，支持超长上下文。

共同趋势：

1. **Decoder-only** 成为绝对主流；
2. **MoE** 广泛用于降低推理成本、扩大参数规模；
3. **多模态原生** 取代"文本模型+外挂视觉"；
4. **长上下文注意力优化**（MLA、滑窗、稀疏注意力等）；
5. **推理时计算扩展**（RL、思维链、测试时搜索）成为新竞争点。

一句话：**底层仍是 Transformer，但已演化为"Decoder-only + MoE + 多模态 + 长上下文优化 + 强化学习推理"的组合架构。**

实践

1、大模型API调用

2、多轮会话agent实现

AI发展的四驾马车

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大模型架构和训练方案

Transformer, RL, MoE等优化方案层出不穷
(OpenAI、Anthropic、Google、字节、DeepSeek 、智谱等)

算力与工程

训练与推理效率显著提高
(英伟达、华为等)

四大驱动力
共同推动AI跃迁

数据与多模态

海量数据覆盖
多模态融合
(互联网、书籍、文献、用户输入等)

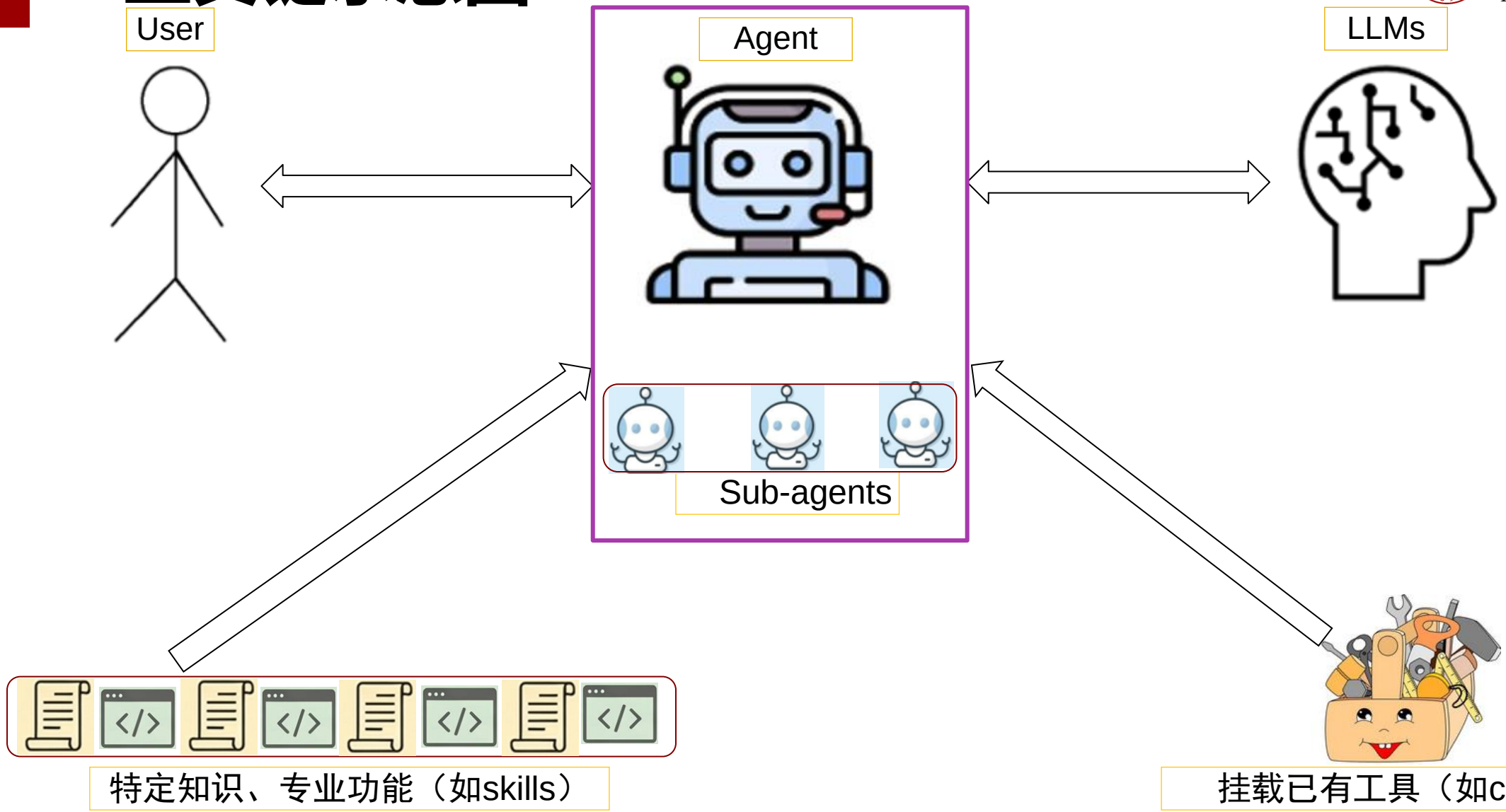
工具链建设

Agents、skills、tools快速发展

目录

- LLM调用及简单使用
- Agent及agent工作流
- 通用Agent及使用

AI工具链示意图



从程序到Agent

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❑传统程序 vs. 智能Agent

- 程序（Program）：被动执行预定义指令的工具。一次输入得一次输出。如计算器、随机数生成器。
- Agent（智能体）：能感知环境、自主决策并执行动作以达成目标的自治实体。它强调与环境的交互和自主性。如扫地机器人、围棋AlphaGo、自动驾驶汽车。

❑Agent = 架构 + 程序

- 程序就是我们要学习的各种AI算法（如搜索、学习、推理、基于Transformer的LLM）
- 架构是让程序能感知、决策、执行的框架

Agent与PEAS描述

❑智能Agent

- 一个通过传感器（Sensors） 感知环境，并通过执行器（Actuators） 对环境施加作用的实体

❑PEAS：系统化分析Agent的框架

- P (Performance): 性能衡量。如何评价它的表现？(e.g., 安全、利润、效率)
- E (Environment): 环境。它在什么中运作？(e.g., 道路、市场、电脑系统)
- A (Actuators): 执行器。它能做什么？(e.g., 转向、下单、操作命令行)
- S (Sensors): 传感器。它能知道什么？(e.g., 摄像头、价格数据、读反馈信息)

PEAS模型实例：自动驾驶汽车

PEAS组件	描述
P (性能衡量)	安全性、通行效率、乘坐舒适度、遵守交通规则
E (环境)	城市道路、高速公路、其他车辆、行人、交通灯、天气
A (执行器)	方向盘、油门、刹车、转向灯、显示屏、喇叭
S (传感器)	摄像头、激光雷达(Lidar)、雷达(Radar)、GPS、IMU

从单一Agent到多Agent系统

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- 复杂任务通常超出单个Agent的能力范围，需要多个Agent分工协作

- 多Agent系统 (Multi-Agent System, MAS):
  - 由多个交互的智能Agent组成的系统
  - 协作: 如何让Agent共享信息、协调行动，共同完成一个全局目标？（如：机器人足球队、供应链管理）
  - 协商: 当Agent目标存在冲突时，如何通过博弈、拍卖等机制达成一致？（如：电子商务中的自动竞价）
  - 通信: Agent之间如何交换信息？（如使用ACL - Agent通信语言）

Agent工作流

❑什么是Agent工作流？

- 将复杂任务分解为一系列子任务，并通过编排或协同 的方式，让一个或多个Agent按照特定顺序、逻辑和规则来协同执行这些子任务的过程。

❑ “分工”与“协作”

- 就像一条流水线，每个Agent是线上的一个专家工人，工作流规定了工作的流转顺序和规则
- 就像软件工程中的“微服务架构”，每个Agent像一个微服务，工作流则是服务间的调用逻辑

Challenges for scientific AI

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- **LLMs' reliability often drops in scientific problem-solving**

- **Caused from the inherent complexity of natural sciences**
  - Long, multi-step and unstructured reasoning
  - Modeling of real-world scenarios
  - Understanding of fundamental laws
  - Implicit constraints
  - Deterministic & probabilistic, precise & approximate
  - …

- **Hard to detect due to logical leaps in the provided answers**
  - Both human and AIs alike tend to omit steps they consider "obvious"

How to address this issue?

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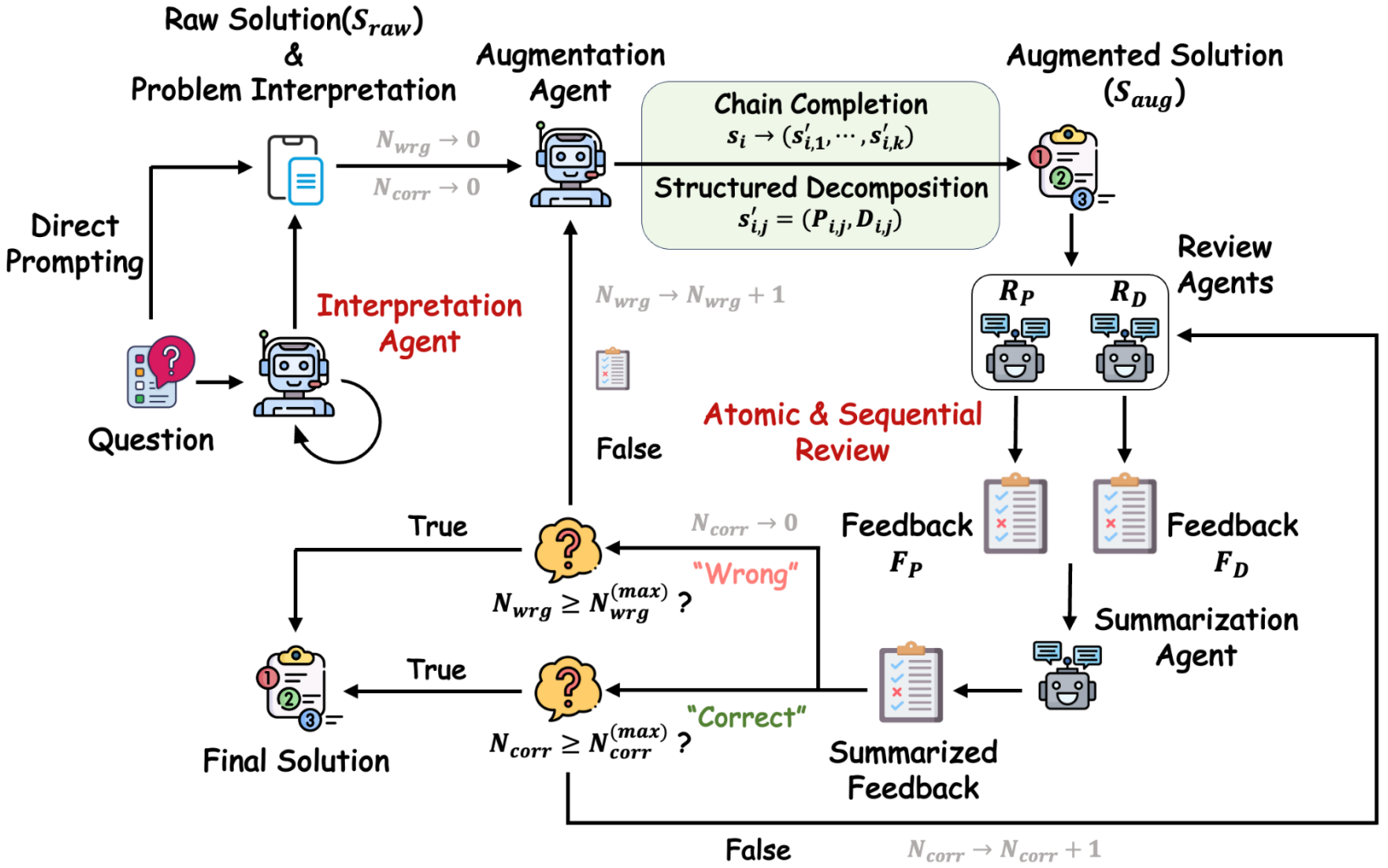
➢ Logical Chain Augmentation (LOCA)

- **Enforcing logical completeness** and **structurally decomposing reasoning steps** into verifiable principles and derivations, within an **augment-and-review** loop

Fang et al., 2510.01249
Jian et al., 2511.10515

Overview of LOCA's pipeline

Jian et al., 2511.10515



Example: raw answer with logical leaps

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➢ For the following question

Question

There is now an electrolyte with thickness L in the z direction, infinite in the x direction, and infinite in the y direction. The region where $y > 0$ is electrolyte 1, and the region where $y < 0$ is electrolyte 2. The conductivities of the two dielectrics are σ_1, σ_2, and the dielectric constants are $\varepsilon_1, \varepsilon_2$, respectively. On the xOz interface of the two dielectrics, two cylindrical holes with a radius R are drilled in the z direction, spaced $2D$ $(D > R, R, D \ll L)$ apart, with centers located on the interface as long straight cylindrical holes. Two cylindrical bodies $\pm$ are inserted into the holes, with the type of the cylinders given by the problem text below.

The cylindrical bodies $\pm$ are metal electrodes filling the entire cylinder. Initially, the system is uncharged, and at $t = 0$, a power source with an electromotive force U and internal resistance r_0 is used to connect the electrodes. Find the relationship between the current through the power source and time, denoted as $i(t)$.

- **Non-atomicity**
- **Implicit justification**

➢ The raw answer is

Raw Answer

Given the potential difference u, it can be seen:

$$\varphi_+ = u/2, \varphi_- = -u/2, \lambda = \frac{2\pi(\varepsilon_1+\varepsilon_2)\varphi_+}{2\xi_+} = \frac{\pi(\varepsilon_1+\varepsilon_2)u}{\text{arccosh(D/R)}}$$

Select a surface encapsulating the cylindrical surface and examine Gauss's theorem. For the positive electrode, it is easy to see:

$$\iint \vec{E}\cdot d\vec{S} = L\oint \vec{E}\cdot \hat{n}dl = \frac{\lambda L}{(\varepsilon_1+\varepsilon_2)/2} = \frac{2\pi u L}{2\text{arccosh}(D/R)}$$

Since the above potential distribution is deemed directly applicable for the calculation of current, the total current flowing out of the positive electrode is:

$$I = \iint \sigma\vec{E}\cdot d\vec{S} = \frac{\sigma_1+\sigma_2}{2}\times\frac{2\pi u L}{2\text{arccosh}(D/R)}$$

Given the current i passing through the power source, this current changes the net charge:

$$\frac{d(\lambda L)}{dt} = i - I = i - \frac{2\pi u L}{2\text{arccosh}(D/R)} = \frac{\pi(\varepsilon_1+\varepsilon_2)L}{2\text{arccosh}(D/R)}\frac{du}{dt}$$

According to the loop voltage drop equation:

$$U = r_0 i + u \to u = U - r_0 i$$

$$\to i - \frac{\pi(\sigma_1+\sigma_2)L}{2\text{arccosh}(D/R)}(U - r_0 i) = -\frac{\pi(\varepsilon_1+\varepsilon_2)L}{2\text{arccosh}(D/R)}r_0\frac{di}{dt}$$

$$\to \frac{di}{dt} = \frac{(\sigma_1+\sigma_2)U}{r_0(\varepsilon_1+\varepsilon_2)} - \left(\frac{\sigma_1+\sigma_2}{\varepsilon_1+\varepsilon_2} + \frac{2\text{arccosh}(D/R)}{\pi r_0 L(\varepsilon_1+\varepsilon_2)}\right) i$$

At time $t = 0$, all current should preferentially enter the capacitor. At this time, the initial current is U/r_0, and this differential equation yields:

$$i(t) = \frac{U}{r_0\left(1+\frac{2\text{arccosh}(D/R)}{\pi r_0 L(\sigma_1+\sigma_2)}\right)}\left\{2 + \frac{2\text{arccosh}(D/R)}{\pi r_0 L(\sigma_1+\sigma_2)} - \exp\left[-\left(\frac{\sigma_1+\sigma_2}{\varepsilon_1+\varepsilon_2} + \frac{2\text{arccosh}(D/R)}{\pi r_0 L(\varepsilon_1+\sigma_2)}\right)\right]\right\}$$

Example: complete and structured answer

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➢ The complete and structured answer with logical rigor

Refined Answer 1

Problem Statement Explanation

The problem describes a physical system composed of two semi-infinite electrolytes, separated by the xOz plane.

- **Electrolyte 1**: Occupies the region $y > 0$, with electrical conductivity σ_1 and dielectric constant (permittivity) ε_1.

- **Electrolyte 2**: Occupies the region $y < 0$, with conductivity σ_2 and permittivity ε_2.

Two long, parallel cylindrical metal electrodes, denoted as $+$ and $-$, are placed within this system.

- **Geometry**: The electrodes are of radius R and length L. They are oriented parallel to the z-axis. Their centers lie on the xOz interface and are separated by a distance of $2D$.

- **Assumptions**: The geometry satisfies the conditions $D > R$ and $\{R, D\} \ll L$. The latter condition allows us to neglect end effects and treat the problem as two-dimensional in the xy-plane, with total quantities (like capacitance and resistance) being proportional to the length L.

At time $t = 0$, this system is connected to a power source.

- **Power Source**: An ideal electromotive force (EMF) U with a constant internal resistance r_0.

- **Initial Condition**: The system is initially uncharged, meaning the potential difference across the electrodes is zero at $t = 0$.

The goal is to find the current $i(t)$ flowing from the power source as a function of time.

Step 1: Equivalent Circuit Model

The physical system can be modeled as a simple electrical circuit. The two electrodes immersed in the electrolytes act as a capacitor, storing charge, and simultaneously as a resistor, allowing a leakage current to flow between them through the conductive medium.

- The capacitive nature is due to the storage of electric charge on the electrodes when a potential difference is applied, with the electrolytes acting as the dielectric material. Let's denote the equivalent capacitance as C.

- The resistive nature is due to the flow of charge (ions) through the electrolytes under the influence of the electric field, from the positive to the negative electrode. Let's denote the equivalent resistance of the electrolytes as R_{elec}.

Since charge can be stored on the electrodes while simultaneously leaking through the medium, the capacitor C and the resistor R_{elec} are in parallel. This parallel combination is connected in series with the internal resistance r_0 of the power source with EMF U.

Step 2: Derivation of the System's Capacitance

The total capacitance is the sum of the capacitances of the upper and lower halves of the system, which are connected in parallel.

First, we state the standard formula for the capacitance per unit length, C', between two parallel cylindrical conductors of radius R with centers separated by a distance $2D$ in a uniform dielectric medium with permittivity ε.

$$\boxed{C' = \frac{\pi\varepsilon}{\operatorname{arccosh}(D/R)}}$$

In our problem, the upper half-space ($y > 0$) is filled with electrolyte 1 (ε_1), and the lower half-space ($y < 0$) is filled with electrolyte 2 (ε_2). Due to the symmetry of the electric field about the $y = 0$ plane, we can consider this as two capacitors in parallel.

- C_1: Capacitance of the upper half, in a medium with permittivity ε_1.

- C_2: Capacitance of the lower half, in a medium with permittivity ε_2.

The capacitance per unit length for each half is:

$$C_1' = \frac{\pi\varepsilon_1}{\operatorname{arccosh}(D/R)} \tag{1}$$

$$C_2' = \frac{\pi\varepsilon_2}{\operatorname{arccosh}(D/R)} \tag{2}$$

The total capacitance per unit length, C'_{total}, is the sum of the parallel contributions.

$$\boxed{C'_{total} = C_1' + C_2'}$$

The total capacitance C for the electrode length L is then derived.

$$C'_{total} = \frac{\pi\varepsilon_1}{\operatorname{arccosh}(D/R)} + \frac{\pi\varepsilon_2}{\operatorname{arccosh}(D/R)} = \frac{\pi(\varepsilon_1 + \varepsilon_2)}{\operatorname{arccosh}(D/R)} \tag{3}$$

$$C = C'_{total} \cdot L = \frac{\pi(\varepsilon_1 + \varepsilon_2)L}{\operatorname{arccosh}(D/R)} \tag{4}$$

Step 3: Derivation of the System's Resistance Similarly, the total resistance of the electrolyte is determined by the two parallel paths for current flow through the upper and lower electrolytes.

For a system with a given geometry, the resistance R and capacitance C in a homogeneous medium are related.

$$\boxed{RC = \frac{\varepsilon}{\sigma}}$$

We can apply this relation to each half of our system. - R_1: Resistance of the upper electrolyte with conductivity σ_1. - R_2: Resistance of the lower electrolyte with conductivity σ_2.

$$R_1 = \frac{\varepsilon_1}{\sigma_1 C_1} = \frac{\varepsilon_1}{\sigma_1(C_1' L)} = \frac{\varepsilon_1}{\sigma_1 L}\frac{\operatorname{arccosh}(D/R)}{\pi\varepsilon_1} = \frac{\operatorname{arccosh}(D/R)}{\pi\sigma_1 L} \tag{5}$$

$$R_2 = \frac{\varepsilon_2}{\sigma_2 C_2} = \frac{\varepsilon_2}{\sigma_2(C_2' L)} = \frac{\varepsilon_2}{\sigma_2 L}\frac{\operatorname{arccosh}(D/R)}{\pi\varepsilon_2} = \frac{\operatorname{arccosh}(D/R)}{\pi\sigma_2 L} \tag{6}$$

Since the current can flow through both electrolytes simultaneously, these two resistances are in parallel. The total equivalent resistance of the electrolyte, R_{elec}, is given by:

$$\boxed{\frac{1}{R_{elec}} = \frac{1}{R_1} + \frac{1}{R_2}}$$

Example: complete and structured answer

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➢ The complete and structured answer with logical rigor

$$\frac{1}{R_{elec}} = \frac{\pi\sigma_1 L}{\operatorname{arccosh}(D/R)} + \frac{\pi\sigma_2 L}{\operatorname{arccosh}(D/R)} = \frac{\pi(\sigma_1+\sigma_2)L}{\operatorname{arccosh}(D/R)} \tag{7}$$

$$R_{elec} = \frac{\operatorname{arccosh}(D/R)}{\pi(\sigma_1+\sigma_2)L} \tag{8}$$

Step 4: Formulation of the Governing Differential Equation

Let $i(t)$ be the current from the source and $u(t)$ be the potential difference across the electrodes. Applying Kirchhoff's Voltage Law to the circuit loop:

$$\boxed{U = i(t)r_0 + u(t)}$$

The current $i(t)$ from the source splits into two paths in the parallel combination: a charging current $i_C(t)$ for the capacitor and a leakage current $i_R(t)$ through the resistor.

$$\boxed{i(t) = i_C(t) + i_R(t)}$$

The currents $i_C(t)$ and $i_R(t)$ are defined by the properties of the capacitor and resistor:

$$\boxed{i_C(t) = C\frac{du}{dt}}$$

$$\boxed{i_R(t) = \frac{u(t)}{R_{elec}}}$$

Combining these, we get a differential equation relating $i(t)$ and $u(t)$.

$$i(t) = C\frac{du}{dt} + \frac{u(t)}{R_{elec}} \tag{9}$$

To find an equation solely for $i(t)$, we eliminate $u(t)$. From the loop law, $u(t) = U - i(t)r_0$. Differentiating with respect to time gives $\frac{du}{dt} = -r_0\frac{di}{dt}$. Substituting these into Eq. equation 9:

$$\begin{aligned} i &= C\left(-r_0\frac{di}{dt}\right) + \frac{U - ir_0}{R_{elec}} \\ i &= -Cr_0\frac{di}{dt} + \frac{U}{R_{elec}} - \frac{r_0}{R_{elec}}i \\ Cr_0\frac{di}{dt} &= \frac{U}{R_{elec}} - i\left(1 + \frac{r_0}{R_{elec}}\right) \\ \frac{di}{dt} &= \frac{U}{Cr_0R_{elec}} - \left(\frac{1}{Cr_0} + \frac{1}{CR_{elec}}\right)i \end{aligned} \tag{10}$$

This is a first-order linear ordinary differential equation for $i(t)$.

Step 5: Solving the Differential Equation The differential equation equation 10 is of the form $\frac{di}{dt} + Bi = A$.

$$\boxed{\frac{dy}{dt} + P(t)y = Q(t) \implies y(t) = e^{-\int P(t)dt}\left(\int Q(t)e^{\int P(t)dt}dt + K\right)}$$

For our constant-coefficient case, the general solution is $i(t) = i_{ss} + i_h(t) = A/B + Ke^{-Bt}$, where i_{ss} is the steady-state current and K is a constant determined by the initial condition.

$$B = \frac{1}{Cr_0} + \frac{1}{CR_{elec}} = \frac{r_0 + R_{elec}}{Cr_0R_{elec}} \tag{11}$$

$$i_{ss} = \frac{A}{B} = \frac{U/(Cr_0R_{elec})}{(r_0+R_{elec})/(Cr_0R_{elec})} = \frac{U}{r_0+R_{elec}} \tag{12}$$

The initial condition at $t = 0$ is that the system is uncharged, so $u(0) = 0$. From the loop law, $U = i(0)r_0 + u(0)$, which gives the initial current:

$$i(0) = \frac{U}{r_0} \tag{13}$$

Applying this to the general solution at $t = 0$:

$$\begin{aligned} i(0) &= i_{ss} + Ke^0 \\ \frac{U}{r_0} &= \frac{U}{r_0+R_{elec}} + K \\ K &= \frac{U}{r_0} - \frac{U}{r_0+R_{elec}} = U\frac{(r_0+R_{elec}) - r_0}{r_0(r_0+R_{elec})} = \frac{UR_{elec}}{r_0(r_0+R_{elec})} \end{aligned} \tag{14}$$

Substituting i_{ss}, K, and B back into the solution gives $i(t)$:

$$i(t) = \frac{U}{r_0+R_{elec}} + \frac{UR_{elec}}{r_0(r_0+R_{elec})}\exp\left(-\frac{r_0+R_{elec}}{Cr_0R_{elec}}t\right) \tag{15}$$

Final Answer

The relationship between the current through the power source and time, $i(t)$, is found by substituting the expressions for the equivalent capacitance C (Eq. equation 4) and resistance R_{elec} (Eq. equation 8) into the general solution (Eq. equation 15).

The steady-state current is:

$$i_{ss} = \frac{U}{r_0+R_{elec}} = \frac{U}{r_0 + \frac{\operatorname{arccosh}(D/R)}{\pi(\sigma_1+\sigma_2)L}}$$

The decay constant in the exponent is:

$$B = \frac{1}{CR_{elec}} + \frac{1}{Cr_0} = \frac{\sigma_1+\sigma_2}{\varepsilon_1+\varepsilon_2} + \frac{\operatorname{arccosh}(D/R)}{\pi r_0(\varepsilon_1+\varepsilon_2)L}$$

The final expression for the current $i(t)$ is:

$$\boxed{i(t) = \frac{U}{r_0 + \frac{\operatorname{arccosh}(D/R)}{\pi(\sigma_1+\sigma_2)L}} + \left(\frac{U}{r_0} - \frac{U}{r_0 + \frac{\operatorname{arccosh}(D/R)}{\pi(\sigma_1+\sigma_2)L}}\right)\exp\left[-\left(\frac{\sigma_1+\sigma_2}{\varepsilon_1+\varepsilon_2} + \frac{\operatorname{arccosh}(D/R)}{\pi r_0(\varepsilon_1+\varepsilon_2)L}\right)t\right]}$$

(8)

目录

- LLM调用及简单使用
- Agent及agent工作流
- 通用Agent及使用

通用智能体现状

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➢ 目的几乎面向编程

智能体	年份	开源	流行度
Cursor	2023	否	高
Cline	2024	是	中
Claude Code	2025	否	高
Codex	2025	是	高
OpenCode	2025	是	高

需要科研专属的智能体：

- 编程不可或缺分，但科研远不止编程
- 当前AI编程智能体并非为科研工作流设计

Aether（以太）通用智能体

北京大学 PEKING UNIVERSITY

- **A**utonomous **E**ngine for **T**heoretical & **H**ands-on **E**xploration in **R**esearch

- 2026.3.25首次发布

  - 基于**OpenCode**开发，打造国际顶级教学科研**AI**智能体
  - 便利的安装、使用
  - 大量免费模型供使用

https://aether.aiphys.cn/

案例：计算前的澄清

Step 1

First clarifies scope and checks the environment.

- Interprets the task before launching tools.
- Finds a configuration issue before heavy computation.
- Makes assumptions explicit and asks targeted clarifications.

Careful collaborator, not a black-box executor.

两圈四点doublebox主积分在s=1,t=10展开计算

请帮我计算两圈四点doublebox拓扑的主积分在运动学量s=1, t=10下的结果，展开到维数正规化因子epsilon的正1阶。

已探索 4 次读取, 1 次搜索

Shell Checks AMFlow environment status

已探索 1 次搜索

我先检查了本机环境：`Mathematica` 和 `AMFlow` 都能找到，但当前 `Blade` 的路径配置需要先修一下，否则没法真正跑两圈积分。

我这里有一个关键歧义需要你确认，我建议默认这样做：

- 按“无质量平面四点两圈 `double box`”标准族来算；
- 外腿满足 `p1^2=p2^2=p3^2=p4^2=0`，`(p1+p2)^2=s=1`，`(p2+p3)^2=t=10`；
- 结果采用 AMFlow 的归一化：每圈 `1/(i*Pi^(D/2))`；
- 并且我自动修复本机 `Blade` 配置后再计算。

如果你同意这个默认设定，我就直接继续算到 `epsilon^1`；如果不是这个族/归一化，请直接给我：

- 传播子列表；
- 你说的“主积分”具体是哪一组；
- 归一化约定。

案例：基于任务描述执行

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Step 2

After the scope is fixed, Aether executes the toolchain and returns a reproducible result.

- Computes the requested integral and epsilon expansion.
- Returns result, script path, output path, logs, and runtime.
- Preserves provenance for inspection, rerun, and reuse.

Results come with files, logs, and execution traces.

按你确认的无质量平面两圈四点 double box 标量主积分 j[dbox,1,1,1,1,1,1,1,0,0] 在 s=1, t=10、AMFlow 归一化 1/(i*Pi^(D/2)) 每圈下，展开到 epsilon^1 的结果是

```
I(s=1,t=10) =
- 0.36363636363636363636/eps^4
+ (1.50974560756401050956 - 0.85679799643357997413 i)/eps^3
- (0.3029311826255851266 - 5.0981381811778132198 i)/eps^2
- (10.242754084619124486 + 9.901633151238733831 i)/eps
+ (34.351002915426986934 - 20.708845586141352035 i)
+ (48.059272314275467673 + 78.808210752995366071 i) eps
+ O(eps^2)
```

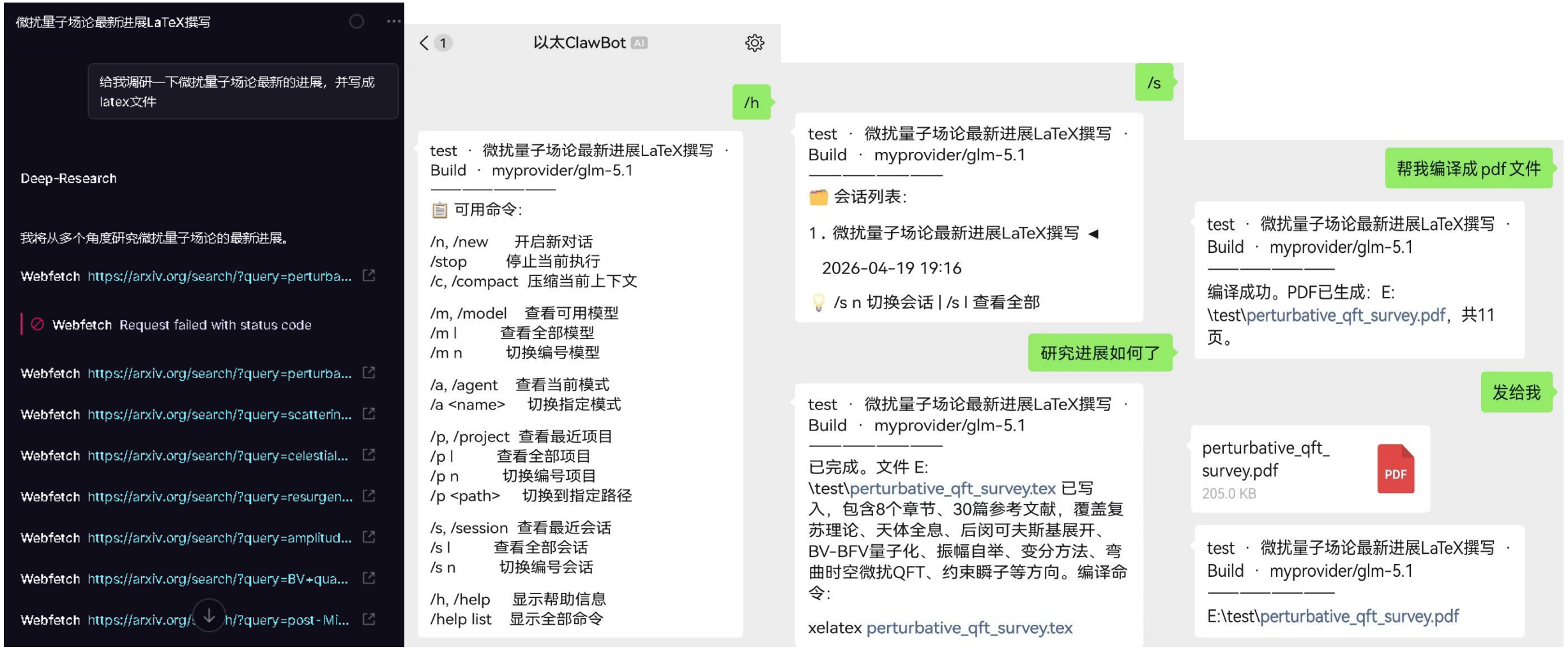
补充信息：

- 计算脚本：amflow_runs/doublebox_s1_t10/run_amflow.wl
- 结果文件：amflow_runs/doublebox_s1_t10/result
- 日志文件：amflow_runs/doublebox_s1_t10/.amflow_log
- 成本估计给出 17 个 eps 采样点，实际 AMFlow 完成时间约 510s，全流程约 708s
- 运行结束时 WARNINGS_DETECTED=0

如果你愿意，我下一步可以：

1. 把这个结果整理成 Mathematica / LaTeX 可直接粘贴的格式
2. 换成你更常用的 double-box 传播子约定再重写一版结果
3. 继续算同一家族的其他主积分或做更高阶 epsilon 展开

案例：移动端同步协作（微信、飞书等）



实践

1、Aether访问/安装
2、Aether使用

谢谢

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