

Prompt-to-Physics: AI To Turbocharge Simulation Workflows

Ian Karakasoglu¹, Daanish Shabbir¹, Isabelle Lee¹, Thorge Lindner¹

¹Equivariant Systems

Abstract

Engineering teams often wait hours or days for a single multiphysics study to be configured, solved, and interpreted. We introduce an AI-centric workflow that embeds large-language-model agents post-trained on computational physics reasoning. These agents can orchestrate COMSOL Multiphysics® workflows, shrinking simulation cycle to minutes while safeguarding model fidelity.

Starting from a plain-language prompt, e.g., "Optimize insertion loss and bandwidth of a silicon-photonics Mach-Zehnder modulator", the agent (1) drafts a detailed execution plan (geometry, material stack, Wave Optics + Heat Transfer couplings, boundary conditions, convergence targets, KPIs); (2) auto-generates COMSOL Java/LiveLink for Python code that implements the plan; (3) runs and monitors the simulation; and (4) extracts and explains results, serving annotated plots and summary metrics in concise domain language. Follow-up queries such as "sweep waveguide width," "apply 85 °C case," or "export effective index vs. wavelength" are handled conversationally; no GUI clicks or manual scripting required. Prompt templates, dimensional guards, and unit-test snippets mitigate hallucinations and ensure traceability.

We evaluated the workflow across a variety of multiphysics scenarios spanning disciplines, scales, and complexity levels. In every case, median setup time dropped by 75-90 % while accuracy stayed within 5 % of expert-built baselines. Complete design-iteration loops—including model updates, reruns, and report generation—were routinely finished several times faster, turning simulation from a bottleneck into a near-real-time decision tool.

The resulting benefits are fourfold: (1) rapid deployment of complex studies, (2) built-in interpretation that turns raw fields into actionable insights, (3) seamless integration with existing engineering data flows, and (4) a lower barrier for colleagues who are not simulation specialists but still need trustworthy results. We will demonstrate a live voice- and chat-driven workflow and share best practices for prompt design, agent guard-railing, and API orchestration.