**Last update on April 29, 2025**

darpa-zenith / DARPA-DSO-Zenith-Code

The modelling and simulation codes which were generated by four performing teams during Phase 1 of DARPA Zenith program which ended in August 2024 are contained in this repository. The objective of the Zenith program is to develop scalable liquid mirrors which can be tilted to cover a large viewing angle and which will benefit the science and astronomy community. The four teams were: General Atomics, General Electric Research, Honeywell and Lockheed Martin.

All enquiries about this repository may be emailed to [zenith@darpa.mil](mailto:zenith@darpa.mil).

A separate issues document is in the Readme folder

The repository is covered under MIT License.

Information on the Zenith program: <https://www.darpa.mil/research/programs/zenith>

**Update on August 21, 2024**

The goal of the DARPA Zenith program is to design, build and test methods by which a telescope, comprising a reflective liquid primary surface held in a light-focusing shape, may be compelled to maintain that shape even if tilted out-of-plane. Four concepts were evaluated during Phase 1 of the program.

* The team led by General Atomics (GA) pursued electrowetting principle of mercury on dielectric coated surfaces, the electrostatic forces acting on the mercury exceeding the gravity forces.
* The team led by GE Research (GE) used the principle that properly designed configuration of magnets and ferrofluids can generate forces much greater than gravity forces. In addition, a capillary layer embedded in the ferrofluid layer can dampen surface instability. As the mirror is tilted, the surface quality is monitored and maintained using an active control with feedback.
* The team led by Honeywell used the principle that a Halbach array of magnets generates a nearly ideal equipotential surface parallel to the top surface of the magnet array in a ferrofluid. The predicted wavefront errors generated when the mirror is tilted are monitored during operation and are removed by active control.
* The team led by Lockheed Martin (Lockheed) used the principle that electromagnetic forces on a ferrofluid can far exceed the gravity force, and their approach comprised a commercial ferrofluid resting on a tiltable parabolic membrane in the proximity of a magnet array.

The modelling and simulation codes which were generated by the four teams are uploaded to this Zenith Github repository to stimulate research interest in tiltable liquid mirrors among the science and astronomy community. The repository is structured with four main branches, one for each approach. The Readme files are listed below.

**Readme files in Zenith Code\_v1**

**GA\_code\_v1\_Github**

* 2407-17263 DARPA ReadMe V1-FinalAppvdR1

**GE\_code\_v1\_Github**

* Code\_Version1\_Documentation\_M&S-Final

**Honeywell\_code\_v1\_Github**

* \_DARPA\_Zenith\_\_Software\_v1\_Report\_withcover
* Zenith\_Optical M&S\_Report\_v1\_rev0

**Lockheed\_code\_v1\_Github**

* Liquid Mirror Ferrofluid Modeling\_V1
* initialInterp\_2\_082224\_edit