# Jorge Casas

jac2440@columbia.edu — jorgecasas.com — linkedin.com/in/jac2440

First-generation Columbia University graduate dual-trained in **astrophysics** and **mechanical engineering**.

## EDUCATION

**Columbia University**, New York, NY **May 2023**
*Bachelor of Arts in Astrophysics*

## PUBLICATIONS & PREPRINTS

– **Casas, J. & Kipping, D.** **(In preparation) 2026**
*Gravitational Slingshots in 3-Body Systems: Energy Amplification and Orbital Scattering.*
– **Casas, J., Li, P., & Zhuang, A.** **Jul 2018**
*Determination of Orbital Elements of 1991 Yuliya PM5 via the Method of Gauss.*
Summer Science Program Technical Report, Team "Altotude," astrometric data archived in MPEC 2018-Q11.

## RESEARCH EXPERIENCE

**Gravitational Slingshot 3-Body Simulation — Columbia University** **Sep 2024 – Present**

– Leading an independent investigation into gravitational assists in multi-body stellar and planetary systems, developing a **Python symplectic n-body integrator** and a **batch-injection pipeline** to simulate thousands of hyperbolic flybys across star–planet and compact-binary architectures.
– Implemented **chaotic-scattering diagnostics** and a custom **MCMC inversion module** to identify high-boost, large-deflection trajectories; validated all results through analytic–numerical comparisons using barycentric monopole reductions.
– Demonstrated that Kepler-432b's three-body dynamics produce a **450× enhancement** in deflection over the matched two-body hyperbola and yield **∼42 km/s** of barycentric $\Delta v$—achieving **4% of the theoretical 180° slingshot limit** and **10% geometric efficiency** at the same approach speed.
– Established that these slingshots operate as low-mass analogs of **Dyson's 1963 gravitational machine**, reaching a few percent of Dyson-level energy efficiency while outperforming the corresponding planet-only prediction by **∼450**× through multi-body dynamical focusing.
– Compared these results to Voyager-class assists: while Voyager's near-optimal two-body Jupiter flyby delivers ∼10 km/s, the Kepler-432b three-body configuration—despite being less fine-tuned—produces a **multi-body boost several times larger** due to the planet's ∼110 km/s orbital speed and strong stellar–planet coupling.
– Future plans to combine exoplanet demographics and binary statistics to estimate the **Galactic population of natural gravity engines**, and explore applications including exomoon stripping, resonance-chain destabilization, and planet-ejection pathways; preparing results for **journal submission**.

**Astrostatistics Projects — Columbia University** **Jan 2023 – Jun 2023**

– **Hubble-Constant Estimation:** Bayesian fit of Type Ia SNe ⇒ $H_0$ and Universe age $14.90 \pm 0.28$ Gyr.
– **Transit Light-Curve Analysis:** Custom MCMC sampler with moving-median filter; depth $1.17{\times}10^{-4} \pm 4{\times}10^{-6}$.
– **Bayesian Stellar Temperature Fitting:** Black-body MCMC model for precise $T_{\rm eff}$ inference.
– **Gliese 581g Validation:** K-fold cross-validated RV modelling to reassess planet claim.
– **Galactic Rotation Curves:** MOND vs. disk + halo dark-matter fits, evaluated with BIC/AIC & $\chi^2$. Bayesian model selection (BIC/AIC/$\chi^2$) for MOND vs. dark-matter halo fits.

**Transit-Timing/Duration Variation Study — Columbia University** **2025 – Future**

– Selected to model exomoon/co-orbital TTV–TDV signatures using the slingshot MCMC toolkit.

**Summer Science Program (SSP) — New Mexico Institute of Mining and Technology & Technology**
Jun 2018–Jul 2018

– Selected for the residential Near-Earth-Asteroid track; led a three-person team "Altotude" over five observing nights with the 0.36 m f/11 C-14 Schmidt–Cassegrain telescope at Etscorn Observatory (Ø14 in., 3.9 m focal length, SBIG STL-1001E CCD).

– Wrote Python pipelines for centroiding, least-squares plate-reduction and differential photometry, achieving $\leq 1''$ astrometric accuracy and $\leq 0.05$ mag photometric uncertainty for asteroid 1991 PM5.
– Implemented a $4^{\text{th}}$-order Method of Gauss with light-time correction to recover heliocentric state vectors; differential correction and a 500,000-trial Monte-Carlo routine yielded converged orbital elements.
– Validated solution against JPL *Horizons* and the Minor Planet Center (all six elements within $1\sigma$); classified the object as an Amor-group NEO (perihelion = 1.28 AU).
– Submitted six astrometric and photometric measurements to the MPC (Obs. Code 719); results appear in MPEC 2018-Q11 and the public MPC catalogue.
– Co-authored a 21-page technical report detailing instrumentation, dark-current calibration, uncertainty analysis and orbital-element derivation; presented findings to SSP faculty and visiting scientists.

## ENGINEERING & FABRICATION EXPERIENCE

**Independent Bi-Liquid Regeneratively Cooled Rocket Engine Development** **Jun 2025 – Present**

– Leading the end-to-end development of a 500 lbf-class regeneratively cooled bi-liquid rocket engine, including thermodynamic cycle definition, structural design, and manufacturability studies.
– Designed and fabricated a fully welded sheet-metal chamber and nozzle contour prototype to validate a low-resource, hardware-first manufacturing pathway in the absence of conventional CNC or additive tooling.
– Developed a custom 1-D regenerative cooling heat-transfer model coupling convective heating from chamber combustion products with conductive and convective heat extraction by ethanol coolant channels to size coolant passages, assess thermal margins, and iterate chamber wall thickness.
– Designed, simulated, and reviewed P&ID diagrams for all fluid subsystems, including propellant feed, pressurization/ullage control, purge lines, and engine conditioning loops; conducted independent checks against industry standards for component sizing and operational safety.
– Secured DymePSI as a project sponsor to supply high-pressure flexible hoses, aluminum fittings, and thermally rated hardware matched to expected chamber pressures, propellant compatibility, and operating temperatures.
– Managing procurement, testing, documentation, and iterative design reviews to transition from prototype geometry to hot-fire-ready hardware.

**Hybrid & Liquid Propulsion Safety & Technical Mentor — FAROUT Rocketry** **Jan 2024 – Present**

– Helped establish the **Friends of Amateur Rocketry: Oxidizers Uninhibited Tournament (FAROUT)**, a collegiate hybrid and liquid-propulsion rocketry competition; contributed to inaugural (2024) site logistics, safety planning, and launch operations.
– Serving as a **hybrid and liquid propulsion safety and technical mentor**, drawing on extensive experience with hybrid nitrous-paraffin engines and student-developed liquid rocket systems; responsible for reviewing propulsion hardware, feed systems, test procedures, and flight-readiness documentation.
– Successfully oversaw and supported **3 of 3 collegiate teams** through safe static-fire and launch operations at FAROUT 2025, including pre-competition evaluations, day-of readiness checks, and real-time decision-making during launch operations.
– For FAROUT 2026, appointed as the **official team mentor** for the Columbia Rocketry Team and **four additional international collegiate teams**, providing ongoing technical guidance, procedural reviews, and propulsion-system safety assessments.
– Contributed to **on-site operations** including pad setup/teardown, range and launch control, safety coordination with FAR and site personnel, contributed to competition documentation and regulations.

**Lead Machinist & CNC Programmer — Columbia ME Teaching Lab** **Aug 2023 – Jun 2025**

– Maintained, restored, and upgraded **10+** machines (Fryer CNC mills with Anilam controllers, Acer engine lathe, Fadal VMC15, Tormach 770/8L, vertical bandsaws, drill presses, sanders), enabling reliable daily use for 500+ engineering students.
– Disassembled, restored, and recommissioned the lab's Fadal VMC15; added ATC capability, tool-offset probing, and flood-coolant retrofits to four Tormach 770 CNC mills, significantly expanding high-precision machining uptime.
– Engineered a complete redesign of a radial-bearing guide block for the legacy bandsaw, eliminating torque-wear failures and preventing **$10k+** in repair or replacement costs.
– Designed and machined custom fixtures; produced **60+ tight-tolerance billet components** (to $\pm 0.001''$) and programmed multi-axis CAM toolpaths in Fusion 360 for student and research projects.
– Developed a **custom Fryer Anilam CAM post-processor** that unlocked modern CAM compatibility on previously G-code-limited machines—effectively adding **two fully CAM-capable CNC mills** to the lab's manufacturing arsenal and enabling larger, more power-intensive student machining operations.

– Digitized and organized a **200+ tool inventory** with Gridfinity storage, implemented a procurement tracker, and authored maintenance SOPs, dramatically reducing downtime and increasing throughput during peak class periods.
– Authored the lab's injection-molding curriculum (written + 4K instructional footage), mentored **250+** students in machining fundamentals, and ran advanced CNC workshops for senior design teams.
– Modeled tool-wear curves to optimize feeds/speeds across aluminum, steel, and Delrin, improving tool life and reducing scrap while standardizing best-practice machining parameters for student use.

**Rocket Project Lead & Propulsion Lead — Columbia Space Initiative** **Sep 2019 – Jun 2023**

– Led Columbia University's undergraduate rocketry program from early concept studies through flight hardware, mentoring dozens of new engineers each year and establishing the team's modern propulsion and structural development pipeline.
– Directed a **50+ member** team in designing, building, and launching Columbia's first **6-inch, 115 lb hybrid rocket**, culminating in a full-scale flight at the **Spaceport America Cup 2023**; coordinated propulsion, structures, avionics, recovery, and test operations.
– Served as **Propulsion Lead** for hybrid-engine development efforts, performing CFD, transient thermal modeling, and high-temperature FEA on graphite nozzles, injector assemblies, and combustion interfaces; validated models through **static hot-fire testing** and thrust-curve correlation.
– Led the structural redesign from a legacy 4.5" airframe to a modular **6.0" composite architecture**, integrating improved load paths, avionics bays, and propulsion mounts optimized for higher chamber pressures and larger impulse-class motors.
– Designed and machined a **4,000 psi-rated feed-block** for embedded pressure transducers and thermocouples for high-fidelity propellant characterization; supported injector design iteration with Python-based **mass-flow and regression modeling** tools.
– Calibrated a **2,000 lbf FUTEK load cell** and built a custom thrust-processing suite for hot-fire diagnostics, including data reduction, filtering, and characterization of burn modes, startup transients, and nozzle performance.
– Developed a strong culture of safety, documentation, and repeatability in propulsion, test, and launch operations forming the foundation for my continued role as a hybrid/liquid propulsion mentor for Columbia Rocketry and FAROUT.

**Welder & Metal Fabricator — GLC Industries, Addison,IL** **Jun 2016 – Jan 2022**

– Performed TIG/spot welding on load-bearing steel assemblies, interpreting engineering prints and QA specs.
– Built custom fixtures, executed weld-penetration checks, and digitized inventory for fiber-laser sheet stock usage.

## SELECTED TECHNICAL & INDEPENDENT PROJECTS

– **Cryogenic $LN_2$ Spray Assembly:** OpenFOAM flow, cryogenic contraction FEA, and CNC machining to seal-tolerance; zero-leak low pressure tests.
– **Solar Tracker:** Dual-axis Arduino PID controller with solar panel array; custom CAD chassis; full-day sun-tracking.
– **Shaker Charger:** Electromagnetic linear generator; Python flux-variation model; optimised damping for max voltage.
– **Injector Flow Suite:** Python models—Dyer choked-flow, two-phase equilibrium, compressible $N_2O$—for real-time mass-flow prediction.
– **Static Fire Stand:** Steel-frame buckling check (SF $>$ 2), FEA of axial/lateral loads, vibration isolation for repeated hybrid rocket engine firings.
– **Data Acquisition:** Dual-load-cell DAQ with noise filtering (scikit-learn, sigma-clipping); thrust and propellant tank mass-loss normalization.
– **Networking and IT:** Architected a segmented home / lab network—isolating IoT, guest, camera, and student VLANs—then added a dedicated 2.4 GHz student VLAN with static IPs for experimental hardware; implemented site-to-site VPN, UniFi Protect video-security rules, and ongoing firmware + ACL maintenance.

## SCIENCE COMMUNICATION & OUTREACH

– **Cool Worlds YouTube — Video Editor & Content Producer** **2022–Present**
  – Edited **30+ long-form astrophysics videos** for the Cool Worlds Lab (10M+ cumulative views), including research explainers, interviews, and documentary-style segments.
  – Storyboarded, animated, and composited motion-graphic sequences on topics such as **gravitational lensing**, **exoplanet detection**, and **dark-matter modelling**, helping translate complex research into accessible visual narratives.

- For the Cool Worlds Podcast, responsible for **active chapter segmentation** by listening for conversational pivots, marking timestamped chapter breaks, and structuring episodes into **5–15 minute thematic sections**.
- Currently collaborating with Prof. Kipping on the creation of a **spin-off podcast-clips channel**; exploring lead responsibilities for **channel management, content curation, and autonomous production**.

## TALKS & PRESENTATIONS

- ***"Fundamentals of Advanced Machining"*** — **Columbia ME Lab Workshop** **Apr 2025**
  - Hands-on campus-wide session covering cutter geometry, feeds & speeds optimization, and GD&T.
  - Demo spurred new tooling guidelines and SOP updates in the teaching shop.
  - Spurred new initiatives to acquire more advanced hardware for CMM tooling for precise measurement.
- ***"Injection-Mold Lab Curriculum"*** — **Author & Instructor** **May 2025**
  - Launched a step-by-step mold-design module with a filmed milling demo.
  - Authored an in-depth manual now adopted across 200-level ME courses.
- ***"Data Analysis & Mass-Loss–Normalized Thrust Curves"*** — **Team Mentor** **Mar 2024**
  - Presented a Python pipeline for cleaning 2,000 lbf load-cell data and mass-normalizing thrust curves.
  - Validated hybrid engine mass flow models against FEA/CFD predictions against single-phase and two phase flow models.

## TECHNICAL SKILLS

- **Programming:** Python (SciPy, NumPy, AstroPy, Pandas, Matplotlib, REBOUND), MATLAB, Mathematica, Arduino/C++, Bash, G-code, Git, Jupyter/Quarto, rsync protocol
- **Astrophysics & Numerical Methods:** Symplectic $N$-body integrators, hyperbolic two-body solvers, ODE integrators, MCMC (emcee), Monte Carlo sampling, Bayesian inference, orbital dynamics, astrostatistics, data modeling & reduction
- **CAD/CAM:** SolidWorks, Fusion 360, Onshape, Blender, HSMWorks, CAM for CNC (3-axis/4-axis), post-processor tuning (Anilam, Fadal/Calmotion)
- **Simulation & Modelling:** ANSYS (FEA/CFD), RPA (Rocket Propulsion Analysis), OpenRocket, thermal/fluid modelling, stress analysis, injector modelling, rocket engine cycle analysis
- **Fabrication:** CNC milling/turning (Fadal VMC15, Tormach 8L), manual machining, TIG/MIG welding, sheet-metal fabrication, 3D printing (FDM/SLA), laser cutting, fixturing, GD&T, metrology
- **Instrumentation:** Load cells (FUTEK), DAQ systems, pressure transducers, thermocouples, pitot/static measurements, Haimer 3D Taster, oscilloscope-based sensor diagnostics
- **Systems & IT:** UniFi OS 9.x, VLAN design, zone-based firewall configuration, AP/switch provisioning, secure home-lab networking
- **Creative Production:** Adobe Premiere Pro, After Effects, Illustrator, Photoshop, Final Cut Pro, Blender (animation), video editing for science communication