A GUIDE TO THE VERIFIED DEPENDENCIES

Chain fountain, gravity and circulation

The v0.18 extension closes the measurable-input / absolute-continuity route for the exact closed-loop family.

78
freshly checked authored theorems
39 v0.17 results rechecked + 39 v0.18 additions

5
zero-gravity modules
91 authored declarations; 144 kernel declarations

20
mapped claim groups
Paper, exact hypotheses and source remain inspectable

Three views. One explicit arrow convention.

Exact reference graphs
Page 2 aggregates references by module; pages 4–9 show selected authored-declaration views. Both use the compiled Lean environment. An arrow points prerequisite → dependent. Solid arrows are proof/body references; dashed arrows are type-only references. Repeated uses count once. No transitive reduction is applied to the new declaration panels.

Semantic reading route
Page 3 explains how the AC construction, uniqueness, estimates and mechanical reconstruction fit together. Its arrows are pedagogical relationships, explicitly distinguished from extracted Lean references.

Current verification
The five zero-gravity modules and their complete local import closure were freshly compiled. Every authored theorem and every target-owned generated kernel declaration was axiom-audited. Only the standard axioms propext, Classical.choice and Quot.sound occur.

Historical appendix
Pages 10–23 retain the 14 original v0.16 graph pages and are marked ARCHIVED. Their 557-theorem / 103-module evidence remains historical. The separate audits do not constitute a fresh combined rebuild. The archived graphs concern the original open-fountain deterministic/stochastic model; they do not prove stochastic or transverse dynamics of the new closed loop.

Navigation

Interactive theorem map ↗ **Expanded preprint ↗** **Sources and verification ↗**

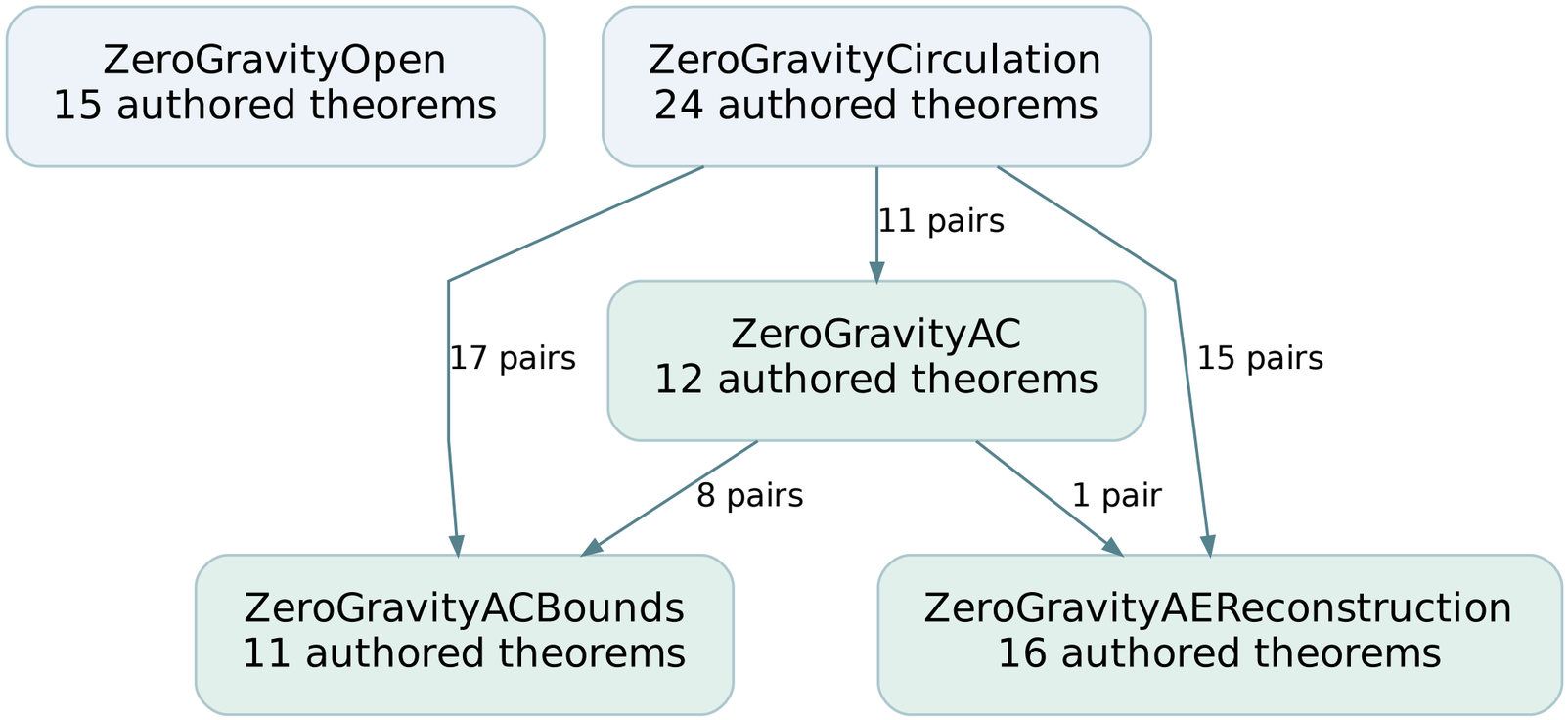
The interactive map uses the opposite viewing direction: declaration → prerequisite. The two displays encode the same dependency relation.

The five modules: actual compiled references

KERNEL-INCLUSIVE AGGREGATION · 144 target-owned declarations · 244 unique direct pairs · 52 cross-module pairs

Each arrow aggregates at least one direct reference in an elaborated declaration type or body. The number is the count of unique prerequisite/dependent declaration pairs. These are not literal module-import edges.

Direct project imports from outside this view (also freshly compiled):
ModelCore → ZeroGravityOpen; ModelCore → ZeroGravityCirculation; AbsoluteContinuity → ZeroGravityAC.

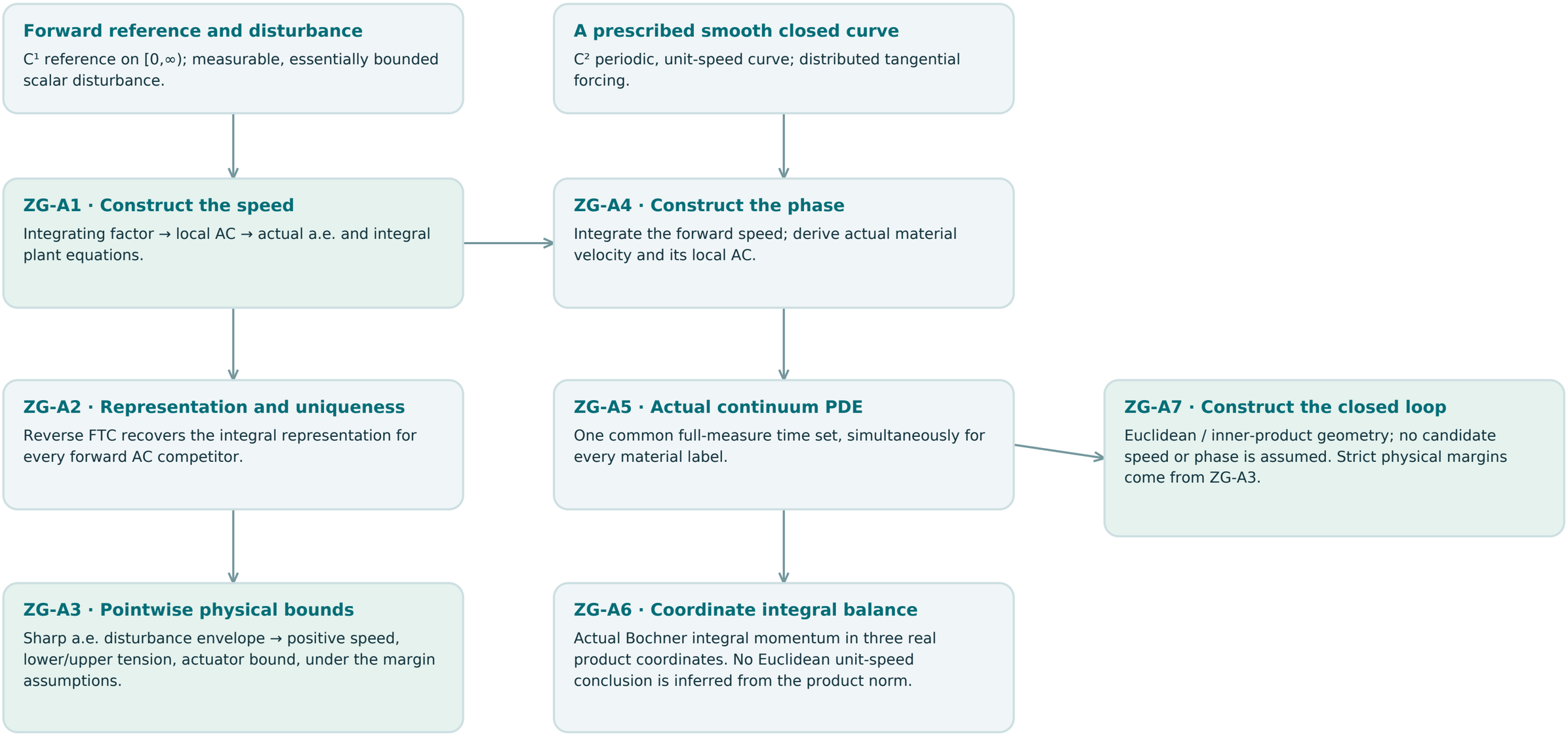


Why the open model stands apart. ZeroGravityOpen has no direct reference pair with another target module. Its underlying fountain definitions and calculus dependencies are outside this five-module view.

No inferred edge. The actual reconstruction wrapper does not use ACBounds. Positive speed, tension and actuator margins are supplied separately by the physical-bound theorem; the diagram does not invent an ACBounds → AEReconstruction dependency.

How the measurable-input proof fits together

SEMANTIC READING ROUTE · These arrows explain the mathematics; they are not extracted declaration edges.



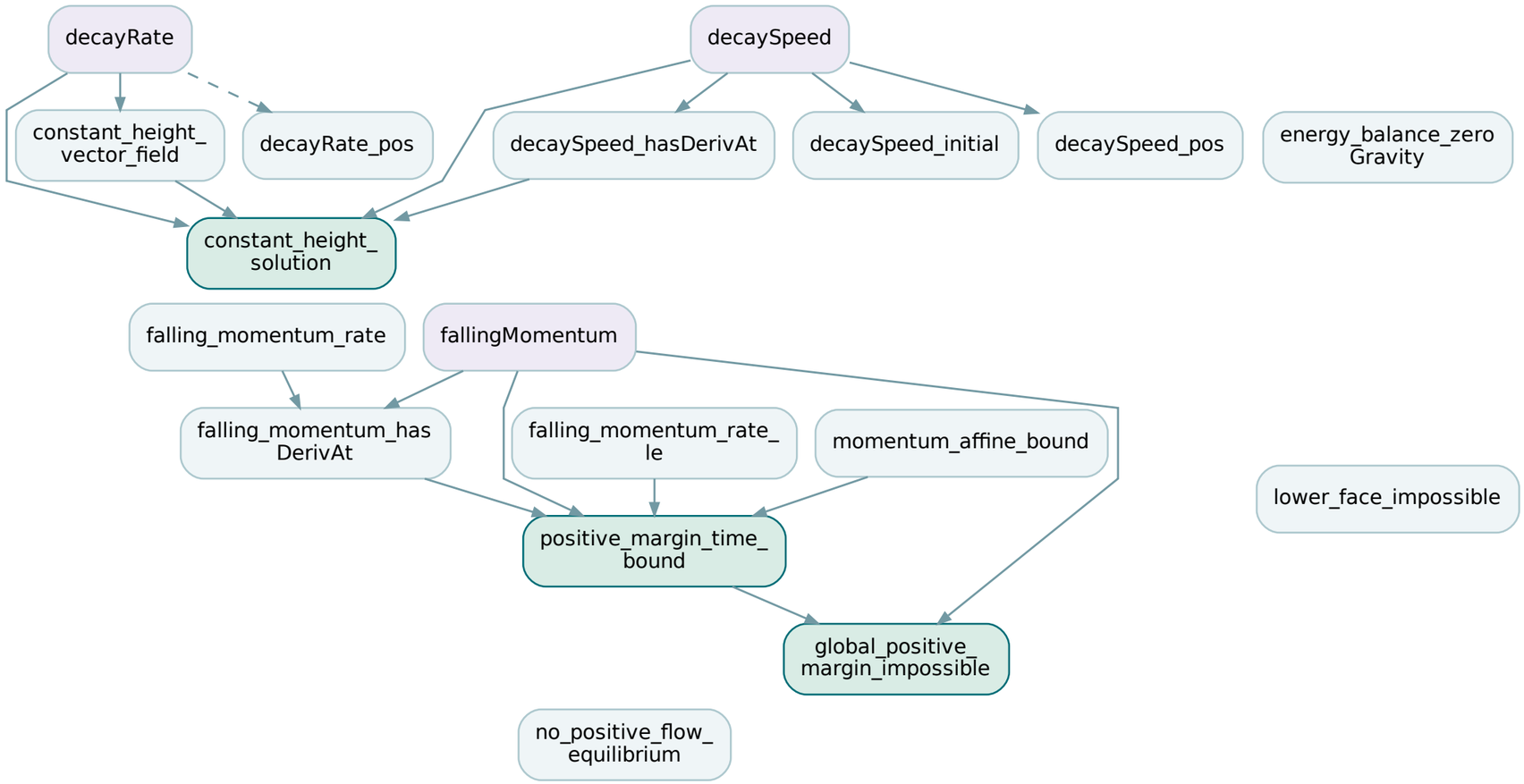
Scope: the geometry is an exact prescribed-curve family. No transverse shape stability, arbitrary-data spatial well-posedness, localized-wheel equivalence, or spatial stochastic model is proved. The coordinate integral branch is kept separate from the inner-product-space inextensibility theorem.

Open transport: the actuator-independent obstruction

ZeroGravityOpen · ZG-O1–ZG-O6 · Exact decay, finite positive-flow horizon and zero-gravity energy.

Exact induced authored-declaration view: 18 nodes and 17 direct reference pairs. Only edges whose two endpoints appear on this panel are shown. Generated helpers, other modules and library prerequisites are omitted, without adding transitive shortcuts.

Namespace omitted from node labels: ChainFountain.ZeroGravity. Green = selected entry point; pale blue = supporting theorem; lavender = definition / structure.



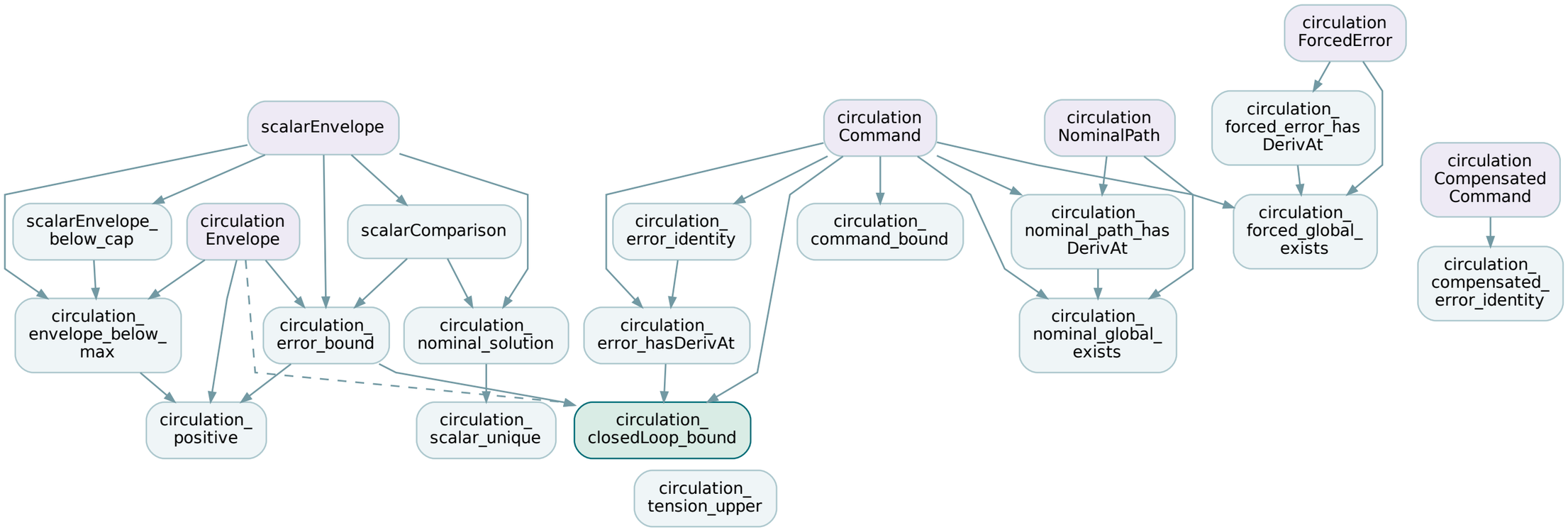
Solid: prerequisite used in the elaborated proof/body. Dashed: prerequisite appears only in the elaborated type. No transitive reduction is applied. The complete 91-node / 174-pair authored and 144-node / 244-pair kernel graphs are retained in JSON. Omitted generated helpers can hide a route: absence of a displayed edge does not establish independence.

Classical circulation: tracking and force margins

ZeroGravityCirculation · ZG-C1–ZG-C5 · Classical subcases remain available alongside the new AC results.

Exact induced authored-declaration view: 23 nodes and 32 direct reference pairs. Only edges whose two endpoints appear on this panel are shown. Generated helpers, other modules and library prerequisites are omitted, without adding transitive shortcuts.

Namespace omitted from node labels: ChainFountain.ZeroGravity. Green = selected entry point; pale blue = supporting theorem; lavender = definition / structure.



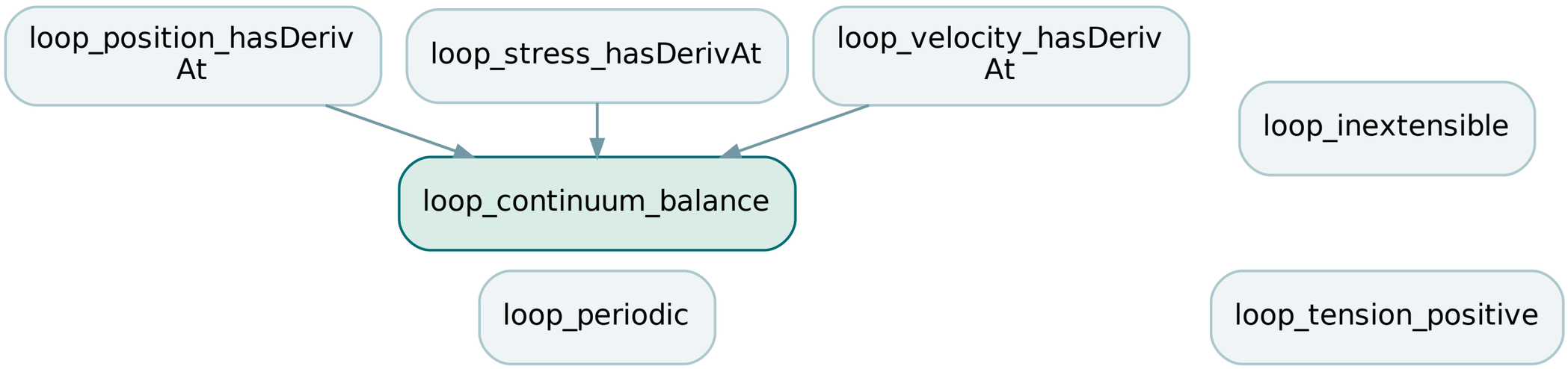
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Classical string reconstruction

ZeroGravityCirculation · ZG-C6–ZG-C7 · Actual chain rules, spatial stress derivative, closure and inextensibility.

Exact induced authored-declaration view: 7 nodes and 3 direct reference pairs. Only edges whose two endpoints appear on this panel are shown. Generated helpers, other modules and library prerequisites are omitted, without adding transitive shortcuts.

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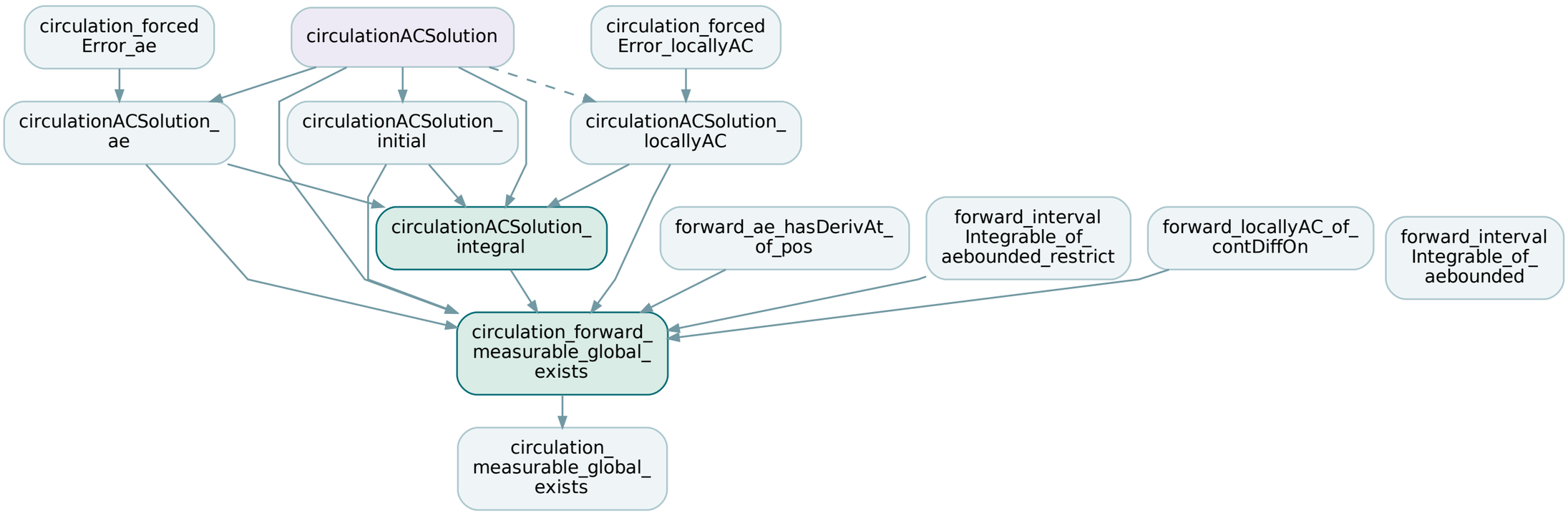
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Measurable forcing: a constructed global-forward AC solution

ZeroGravityAC · ZG-A1 · Initial data → integrating-factor construction → actual a.e. and integral plant equations.

Exact induced authored-declaration view: 13 nodes and 18 direct reference pairs. Only edges whose two endpoints appear on this panel are shown. Generated helpers, other modules and library prerequisites are omitted, without adding transitive shortcuts.

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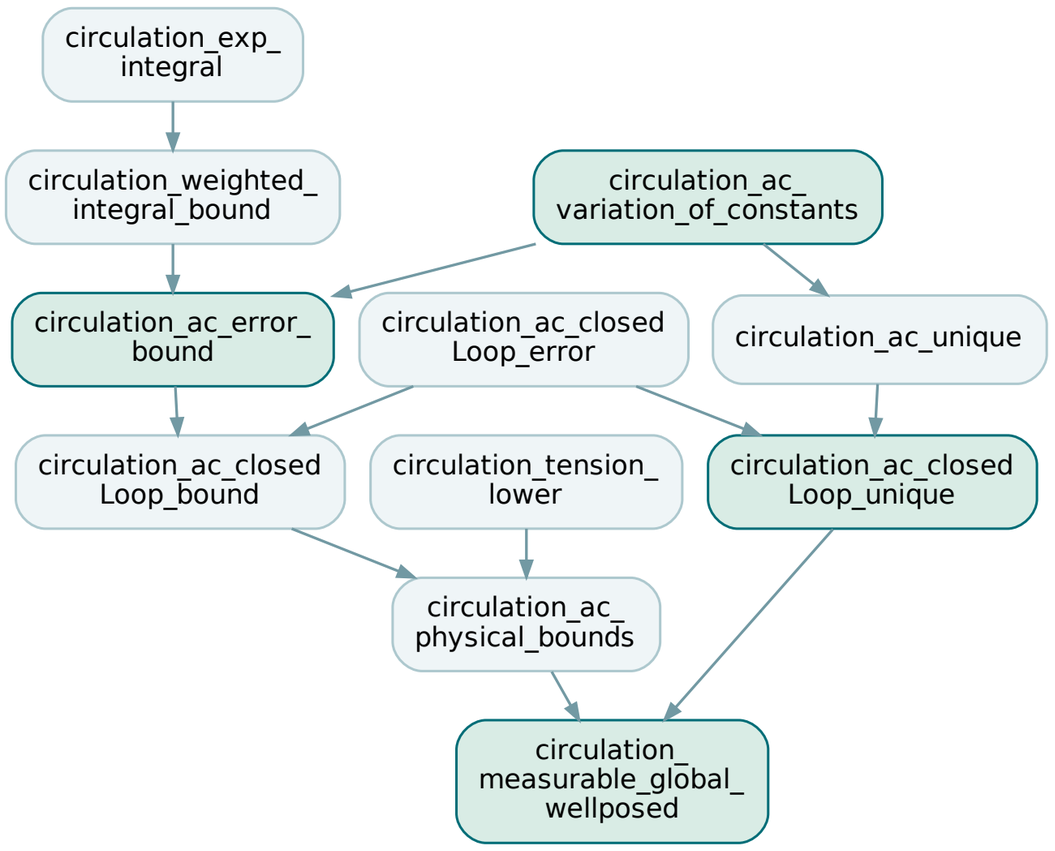
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AC uniqueness and pointwise physical bounds

ZeroGravityACBounds · ZG-A2–ZG-A3 · Reverse FTC, unrestricted forward AC uniqueness, sharp bounds and margins.

Exact induced authored-declaration view: 11 nodes and 12 direct reference pairs. Only edges whose two endpoints appear on this panel are shown. Generated helpers, other modules and library prerequisites are omitted, without adding transitive shortcuts.

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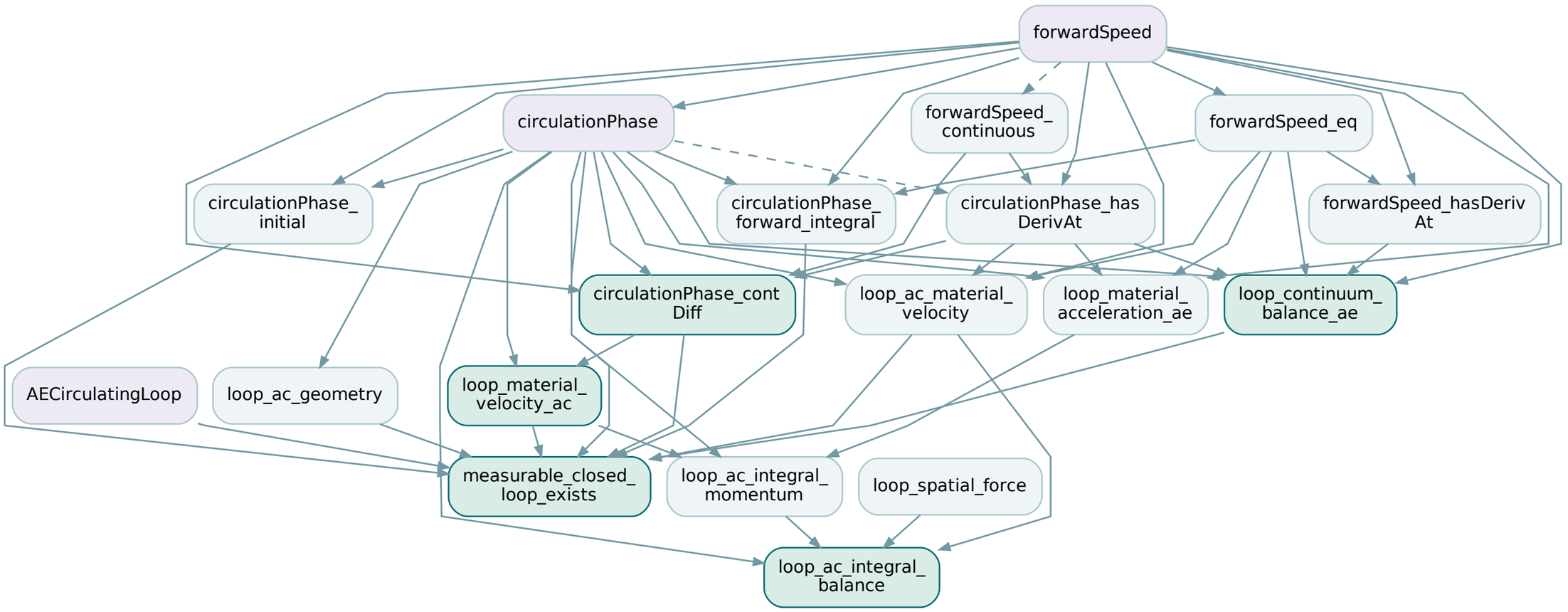
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From the AC speed to the actual continuum balance

ZeroGravityAEReconstruction · ZG-A4–ZG-A7 · Constructed phase, material velocity, common full-measure time set.

Exact induced authored-declaration view: 19 nodes and 49 direct reference pairs. Only edges whose two endpoints appear on this panel are shown. Generated helpers, other modules and library prerequisites are omitted, without adding transitive shortcuts.

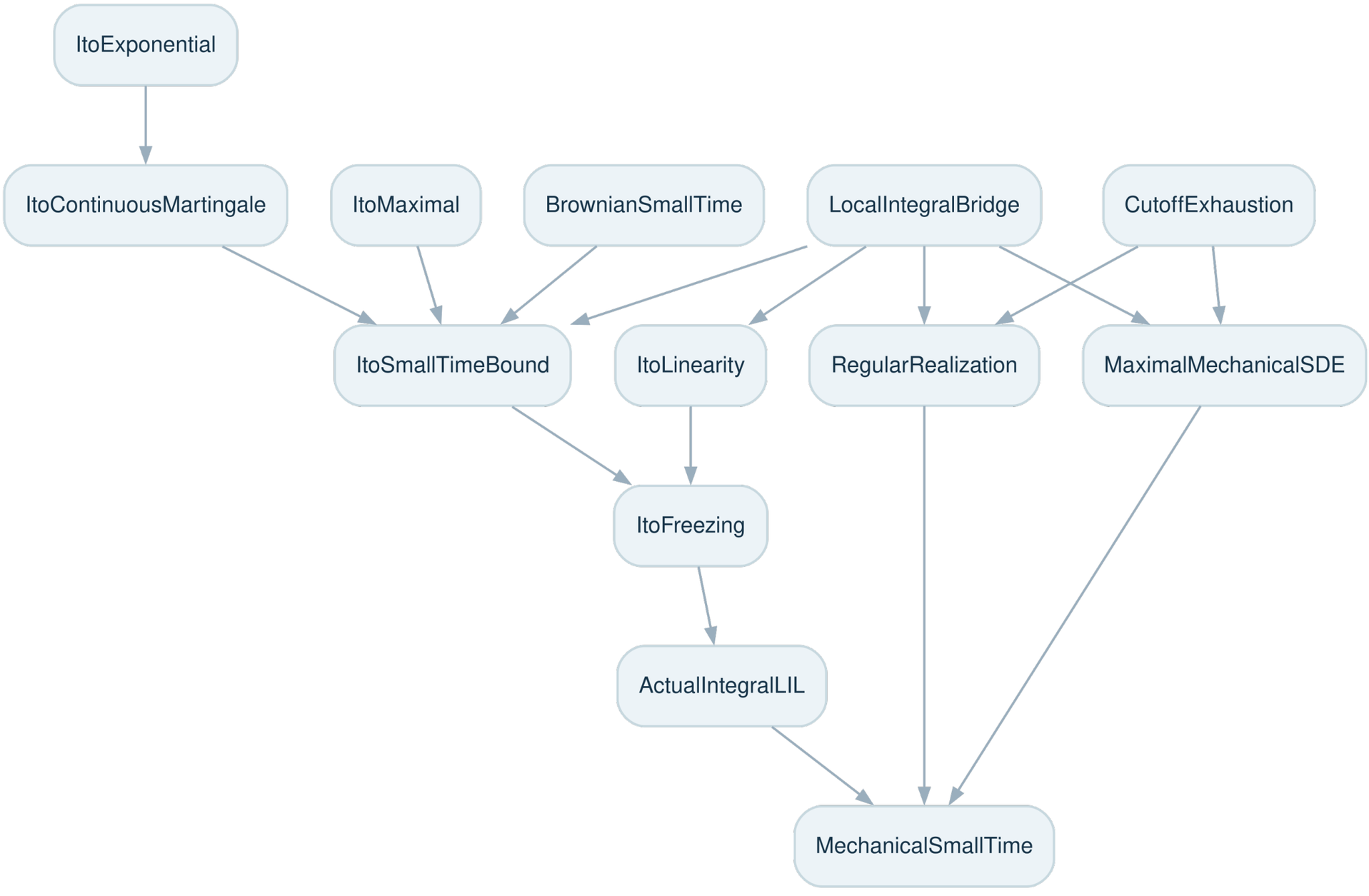
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Quantifiers and geometry matter. The a.e. PDE holds on one common full-measure set for all material labels. The product-coordinate integral lemmas and the inner-product-space geometry wrapper have distinct hypotheses; see ZG-A5–ZG-A7 in the interactive map.

Actual mechanical integral and sharp crown LIL

Exponential maxima · clipping and prefix locality · frozen coefficient · constructed SDE · genuine exit

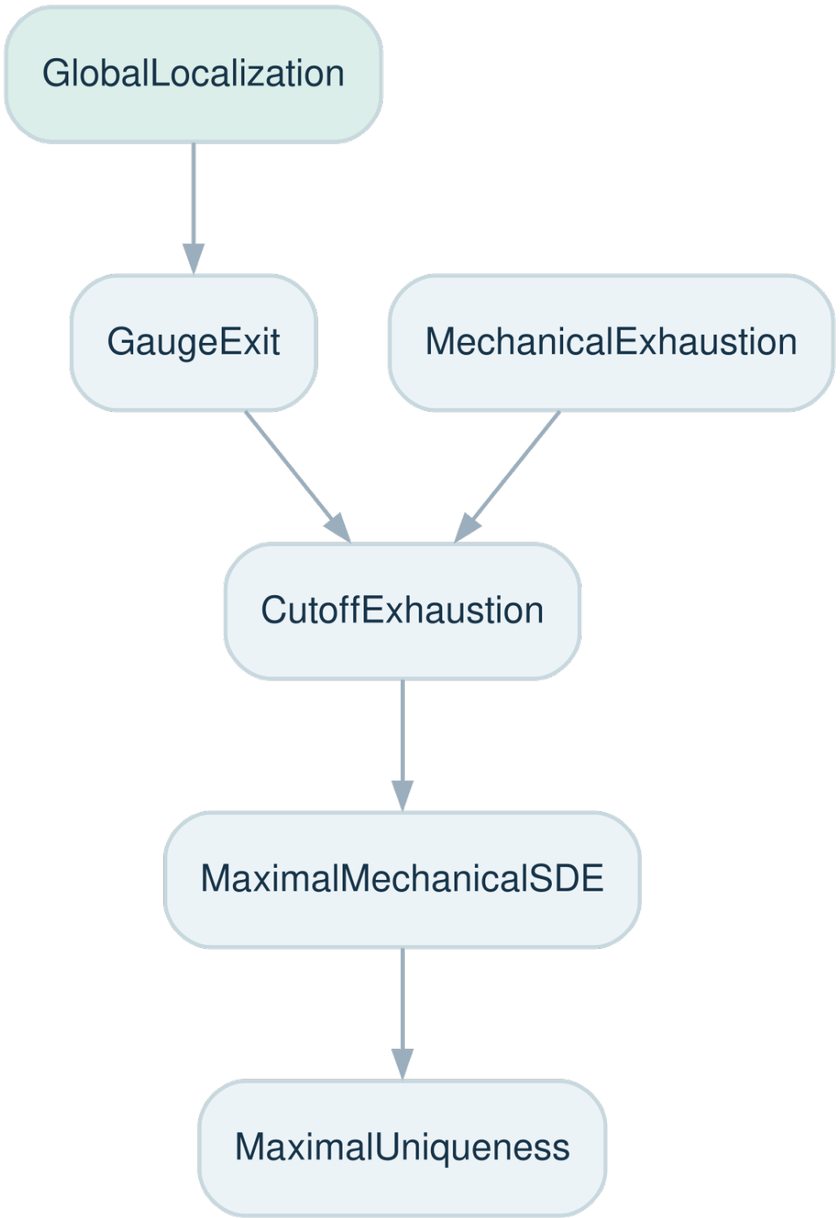


The scalar view shows named theorem dependencies; module views show their transitive reduction.

Full types, assumptions, source and complete theorem dependencies are available in the offline interactive map.

Maximal lifetime and explosion

Compact exhaustion · coherent genuine exits · predictable gluing · compact escape

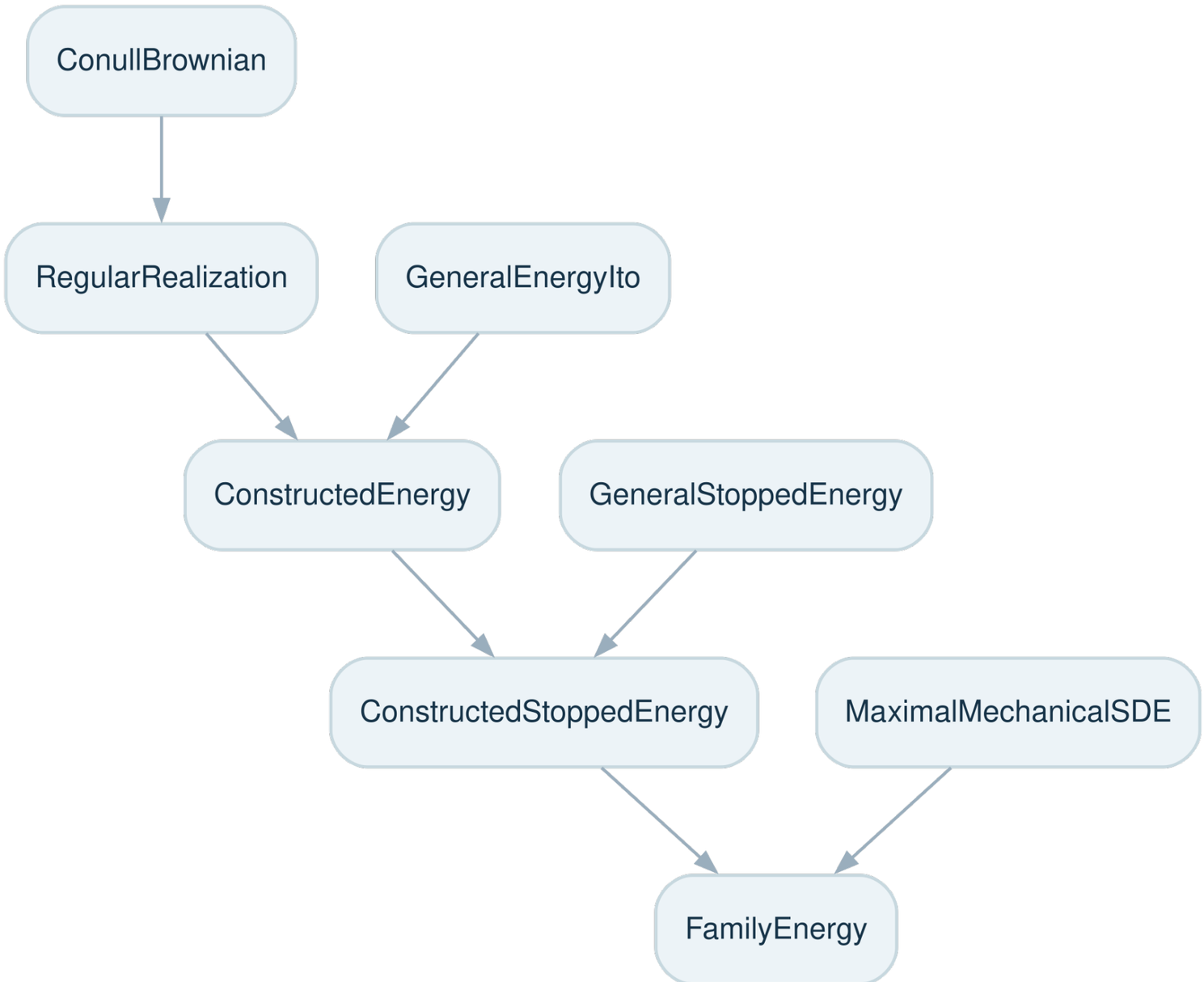


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Energy of the constructed maximal solution

Conull realization · actual Ito identity · bounded stopped martingale · expectation estimate

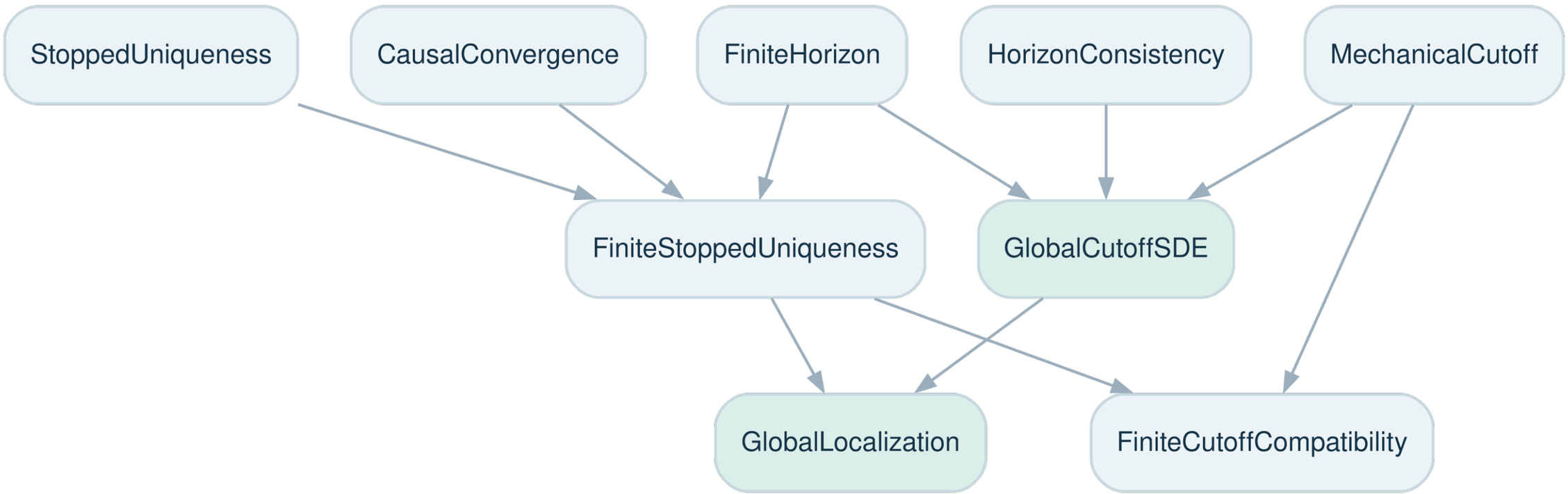


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Global cutoff solutions and uncapped exits

Actual Picard convergence · cross-horizon consistency · global predictable process · equal genuine exits

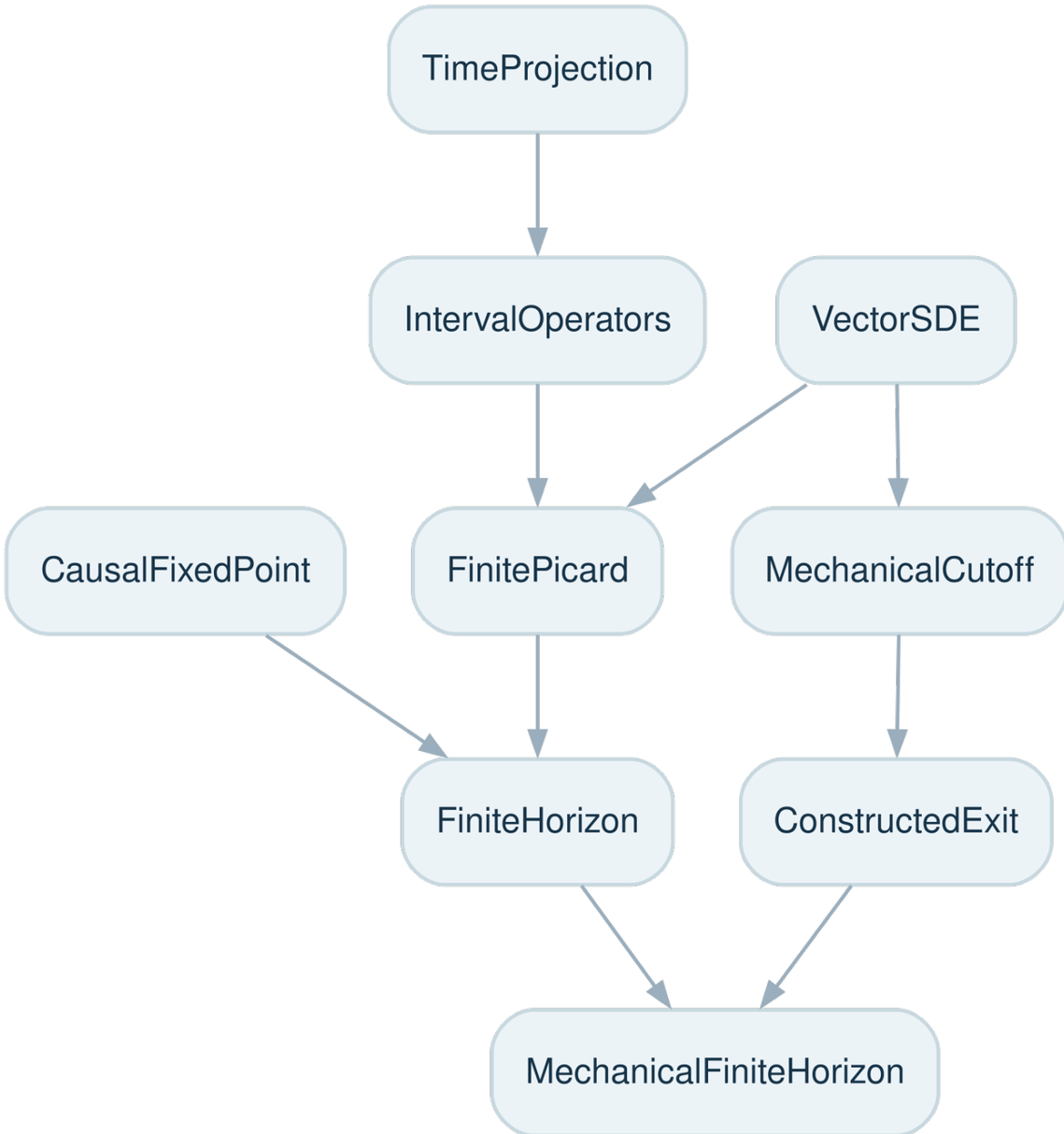


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Strong solutions on every finite horizon

Causal continuation · actual operator estimates · coupled strong existence and uniqueness · mechanical cutoffs

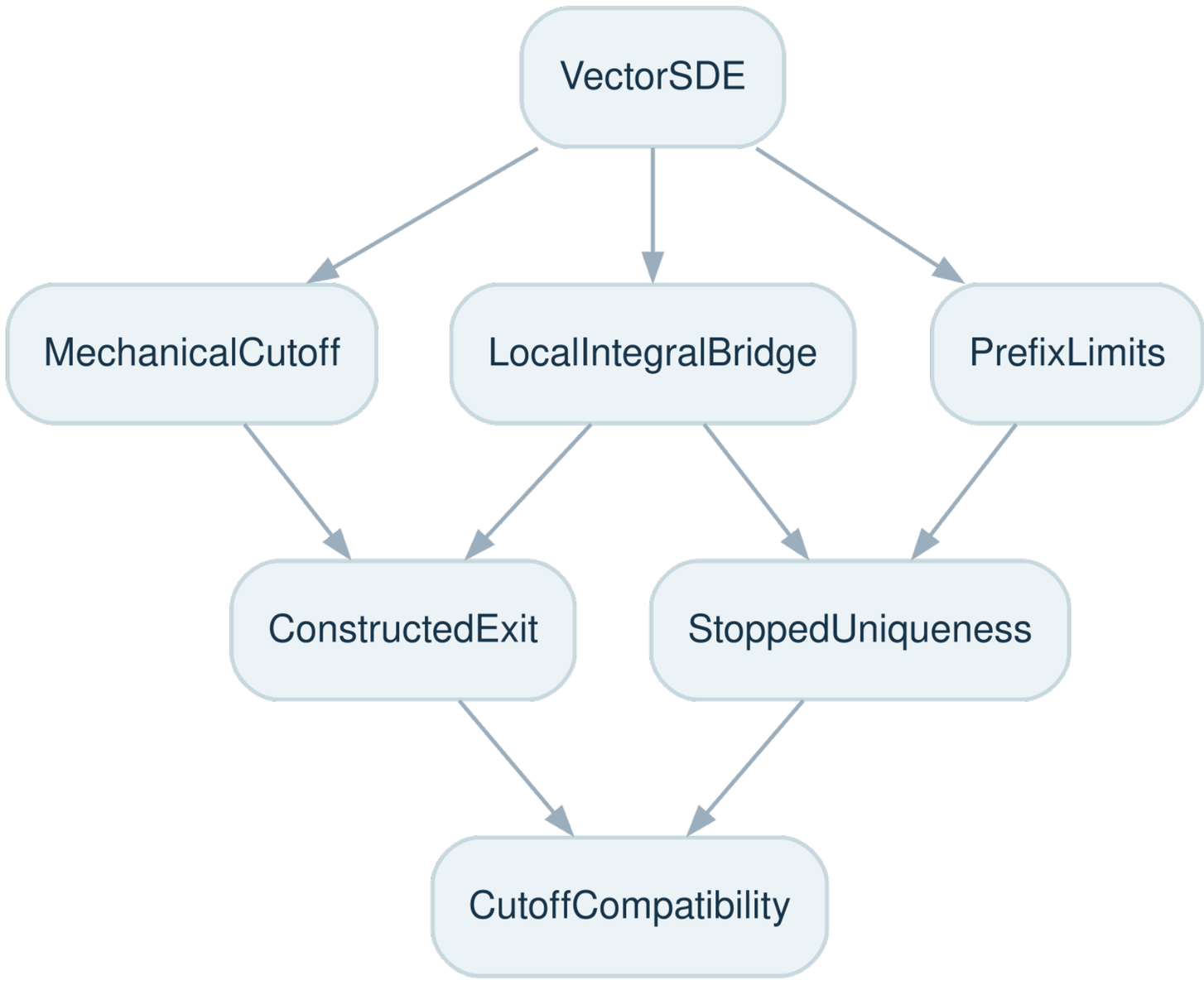


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Local stopped uniqueness and cutoff compatibility

Common positive contraction horizon · equal genuine exits · equal stopped continuous versions

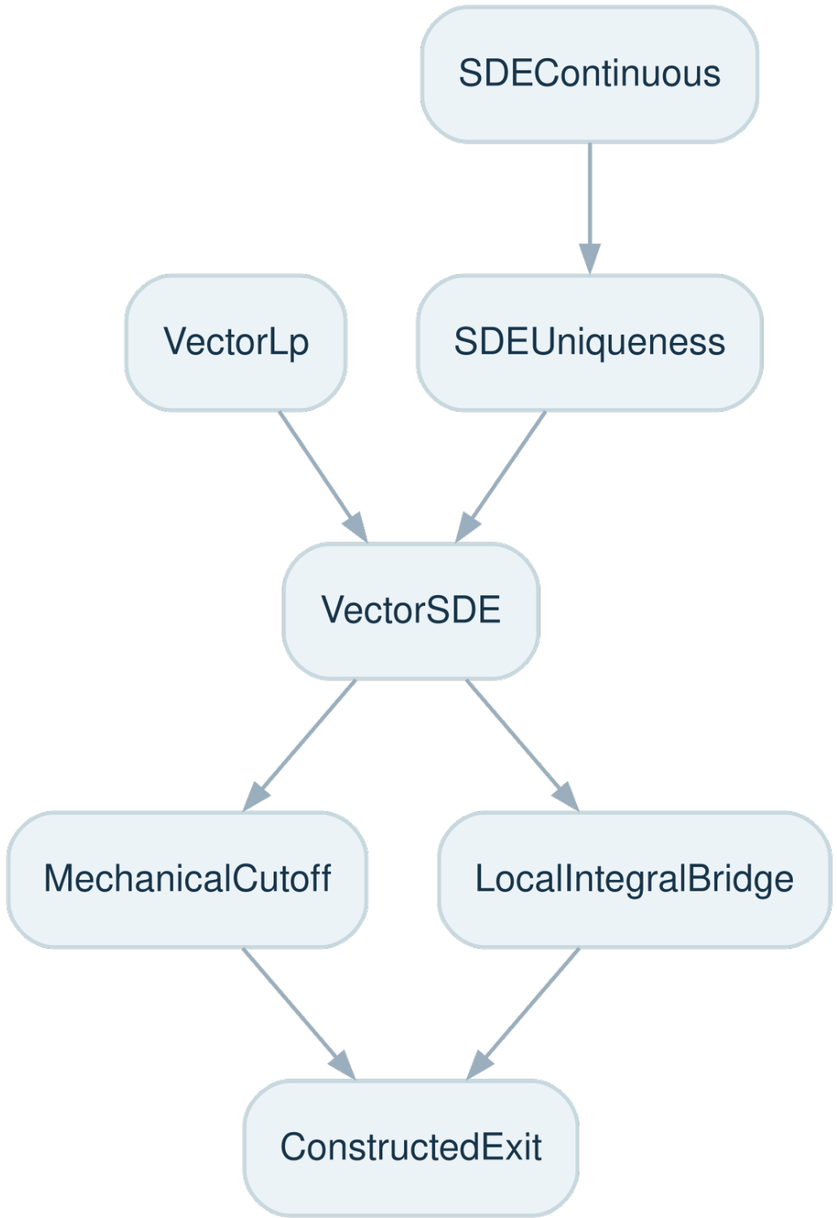


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Constructed solution and genuine random exit

All-times integral realization, augmented-filtration continuity, positive norm-ball exit

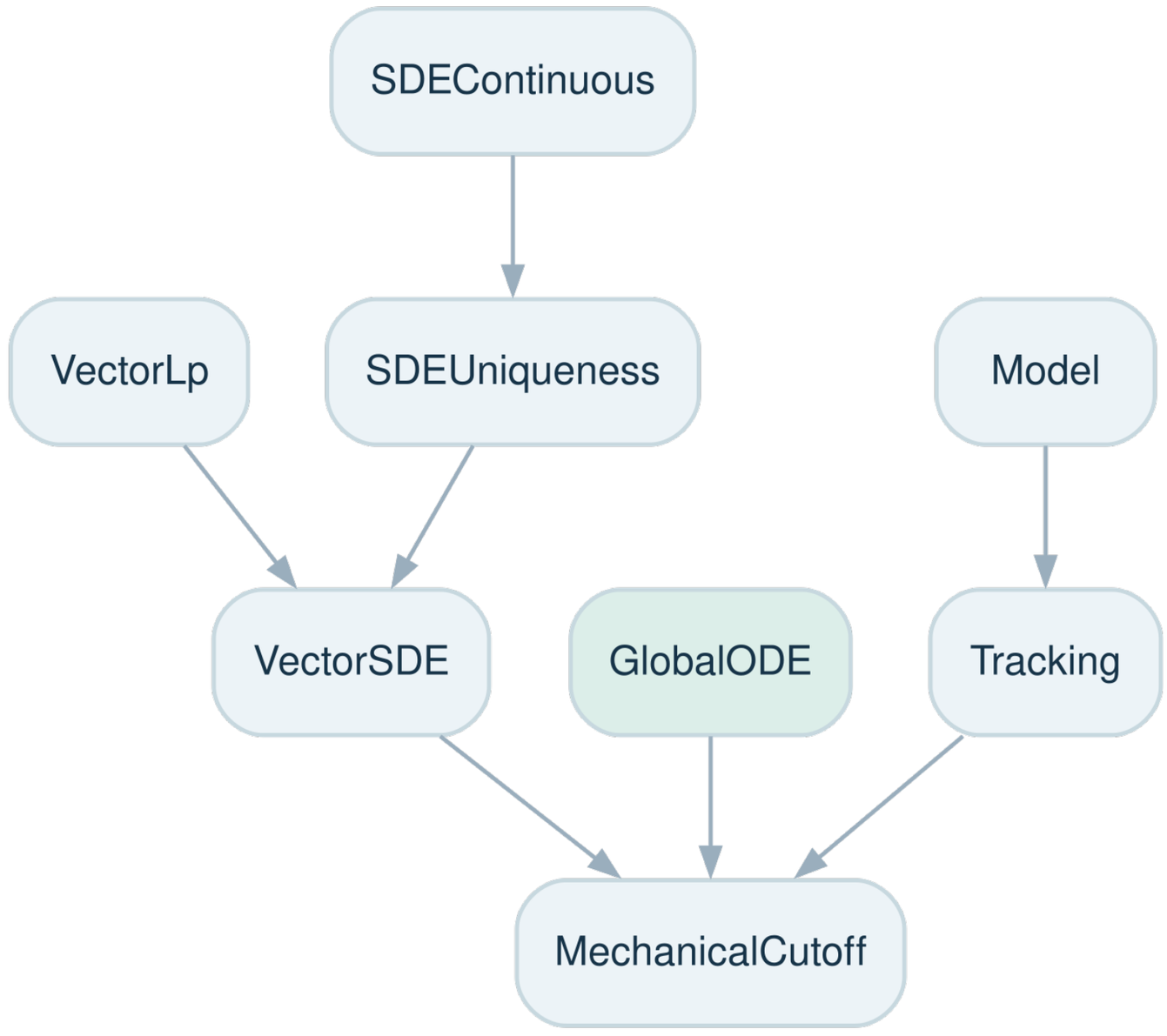


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Coupled SDE construction and mechanical cutoffs

Predictable vector L2, actual trajectory coefficients, original mechanical fields

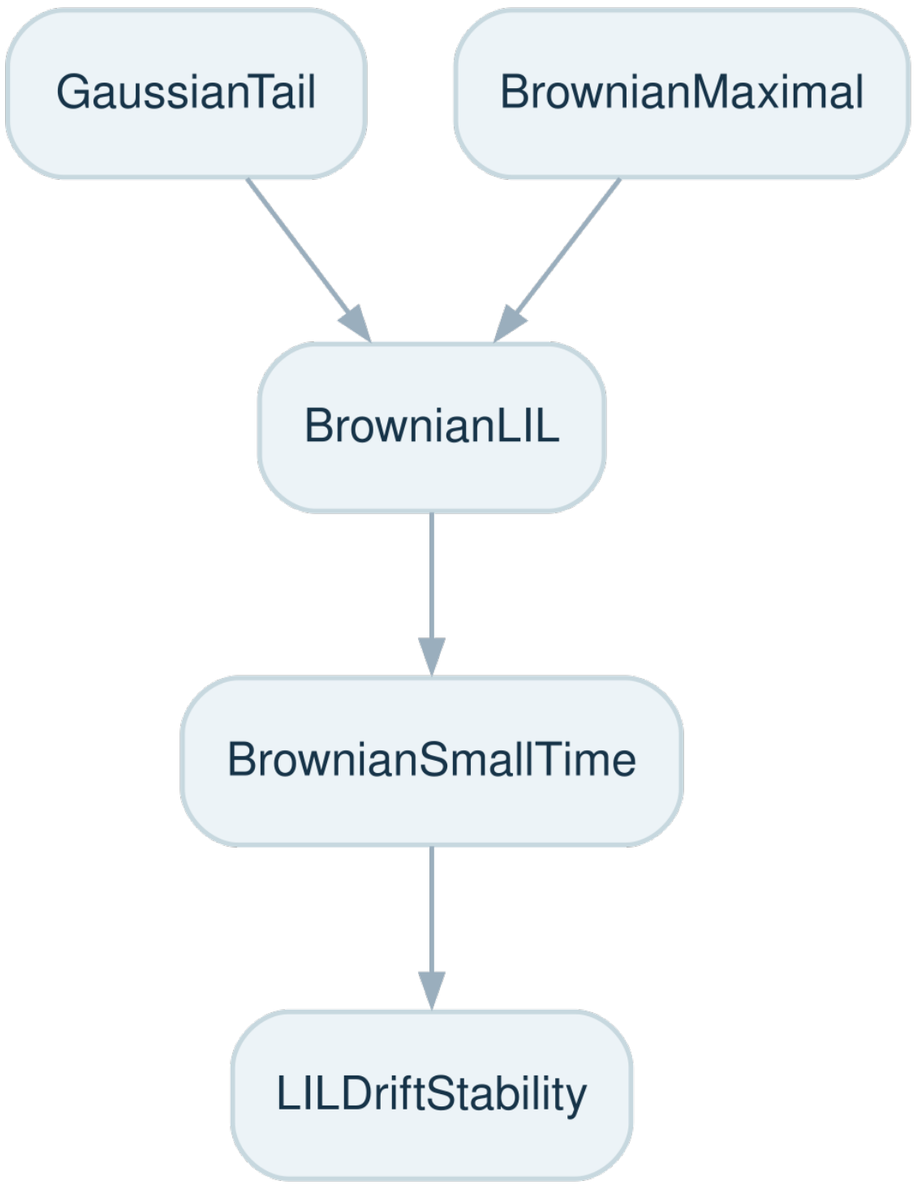


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Sharp Brownian LIL and drift stability

Wald/Doob maximum + normalized Gaussian tail → LIL at infinity → time inversion → small-time limits

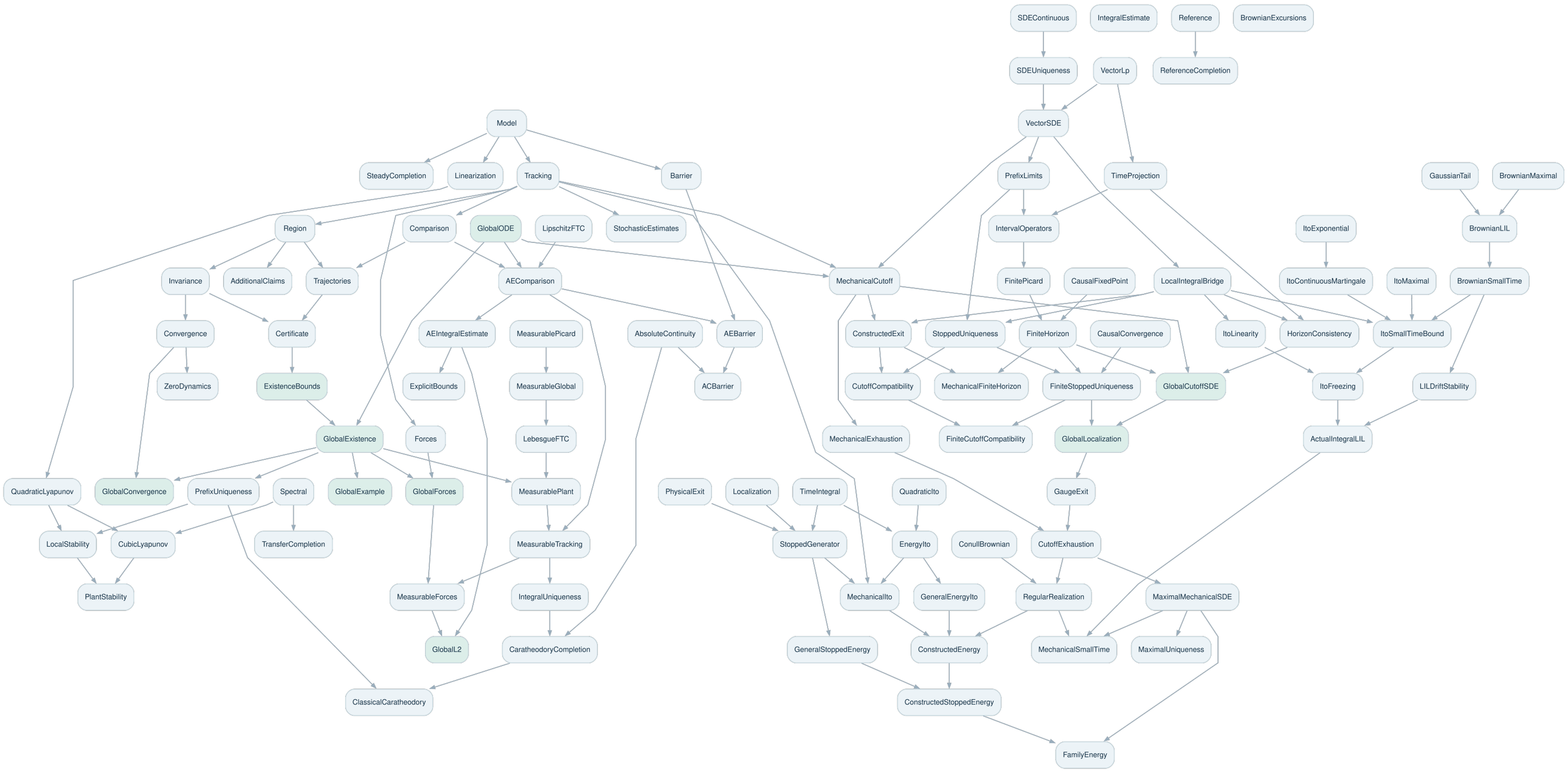


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The verified dependency structure

103 modules · 557 named theorems · arrows: prerequisite → dependent

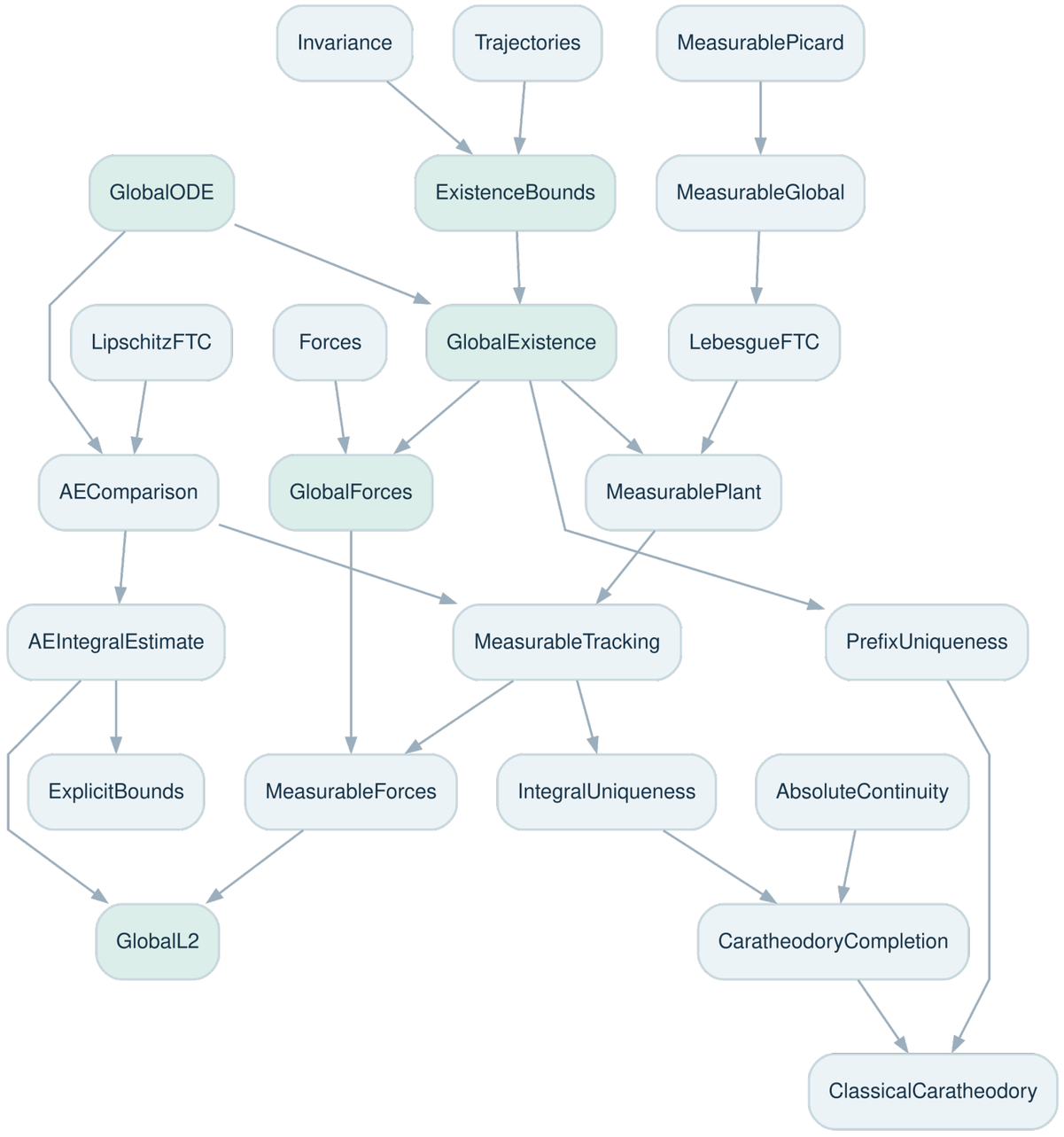


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Measurable input → global physical control

Integral construction, a.e. calculus, invariance and force bounds

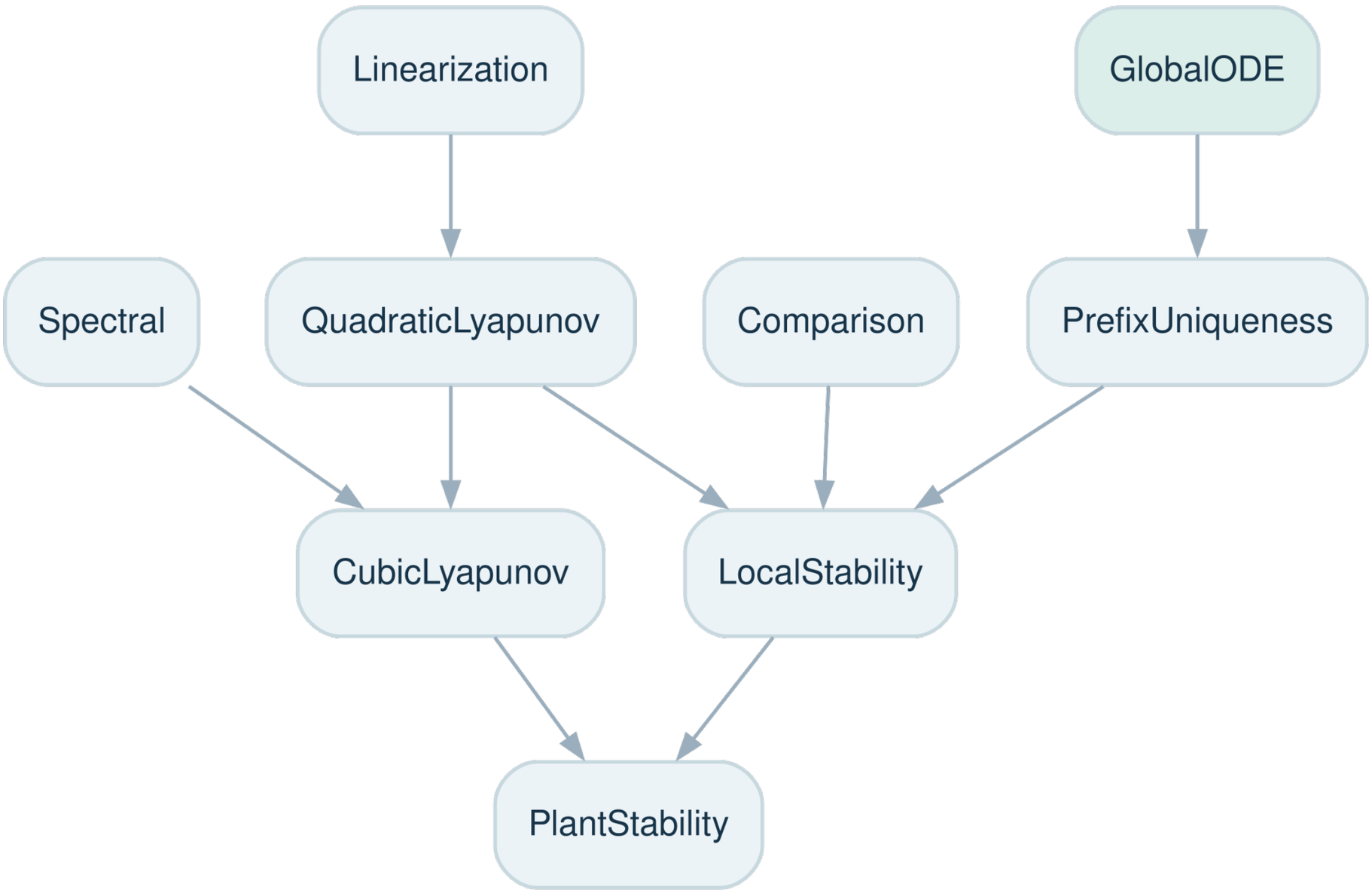


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Nonlinear local exponential stability

The actual derivative → explicit quadratic Lyapunov function → constructed decaying trajectory

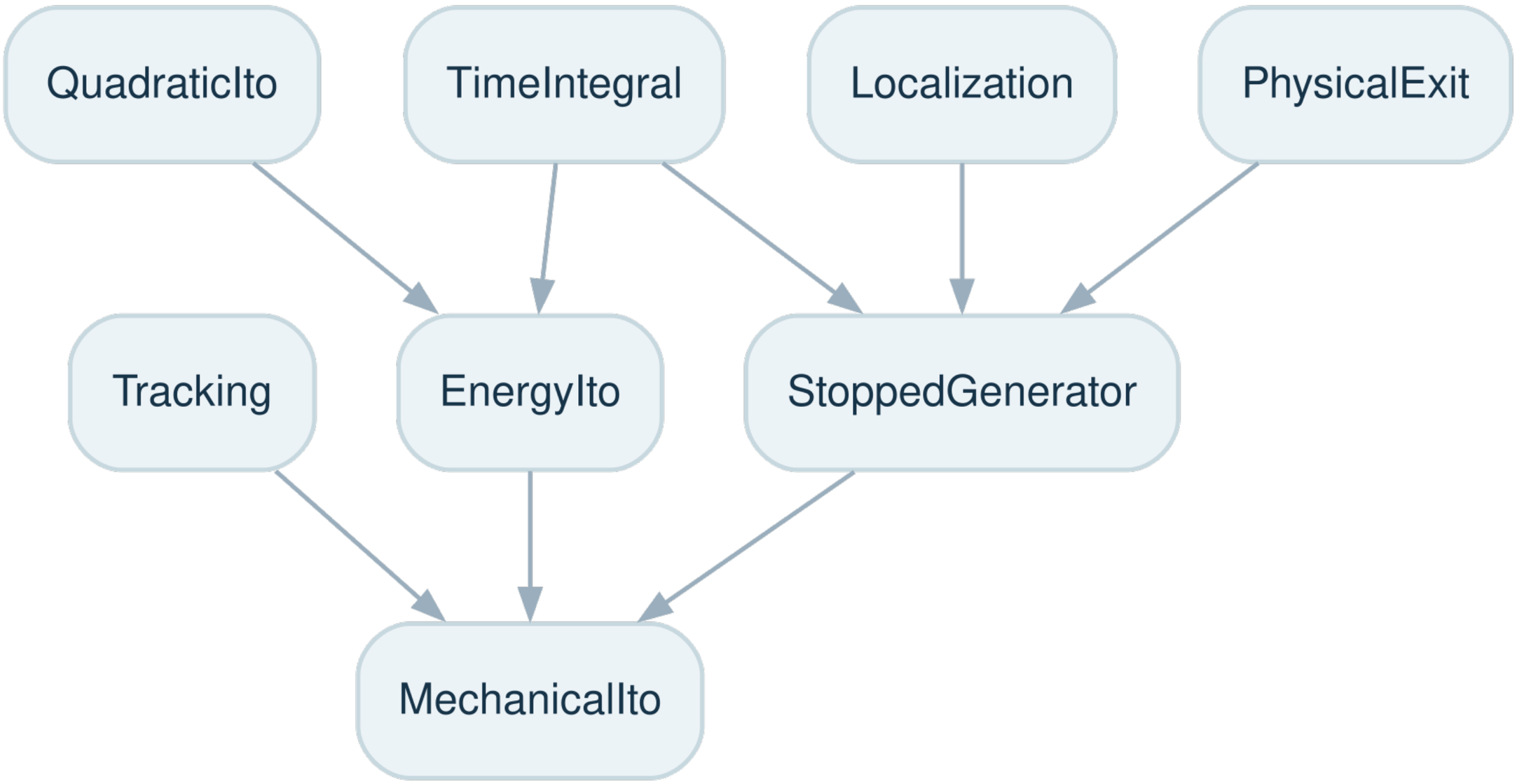


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Mechanical SDE → energy and physical first exit

Unified Lean 4.33-rc1 · checked fixed-horizon solution interface · mechanical LIL transfer checked

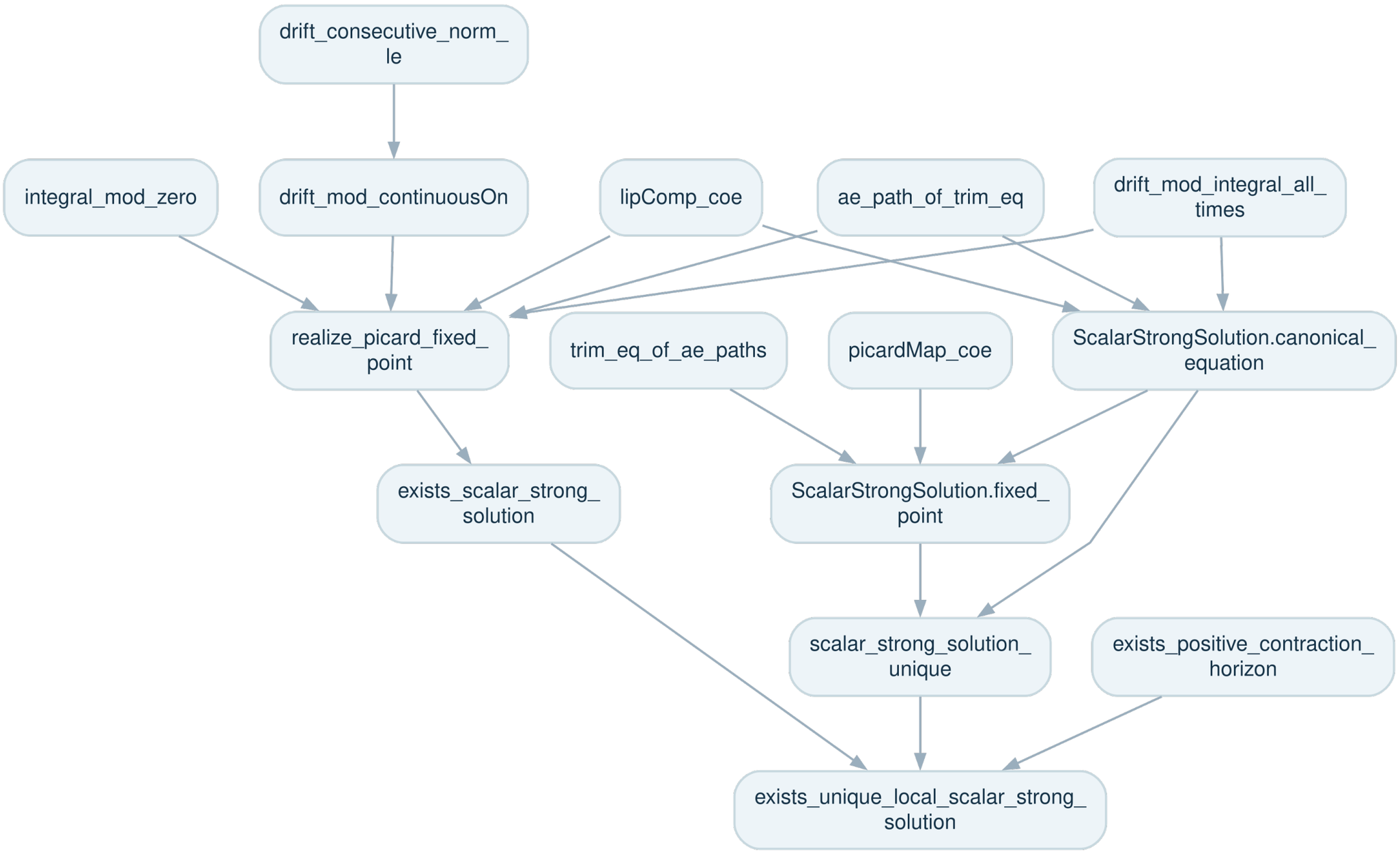


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Scalar strong-solution construction

Autonomous Lipschitz coefficients · actual trajectory composition · positive horizon · pathwise uniqueness



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