Electron–Swirl Coupled Transport in the Vortex Æther Model (VAM): Perturbative Solutions, Quantitative Benchmarks, and Falsifiable Experiments

Omar Iskandarani

2025

Abstract

We present a self-contained treatment of electron–swirl transport in VAM that (i) derives a *perturbative, steady-state* solution to the coupled density-matrix equations in 1D; (ii) provides *quantitative* predictions for realistic tabletop experiments with explicit material recommendations and signal levels; and (iii) states *falsifiability criteria*. The theory recovers Peierls (population) and Allen–Feldman (coherence) limits [1–3] while embedding electrons as vortex-knots coupled to swirl modes [4, 5]. Numerical scales are fixed by VAM constants $C_e = 1.09384563 \times 10^6\,\mathrm{m/s}$, $r_c = 1.40897017 \times 10^{-15}\,\mathrm{m}$, $\rho_{æ} = 7.0 \times 10^{-7}\,\mathrm{kg/m^3}$.

1 Scales from VAM

Define the characteristic swirl frequency and energy density

$$\Omega_0 \equiv \frac{C_e}{r_c} \approx 7.76 \times 10^{20}\,\mathrm{s^{-1}}, \qquad \varepsilon_{æ} = \tfrac{1}{2}\rho_{æ} C_e^2 \approx 4.19 \times 10^5\,\mathrm{J/m^3}. \tag{1}$$

In what follows, frequencies and rates are reported in units of Ω_0 when convenient, but all experimental predictions are in SI.

2 Coupled transport in 1D and perturbative solution

We adopt the unified density-matrix equation for bosonic modes $N(\mathbf{R}, \mathbf{q})$ [3] and extend it by a charged two-level system ("electron") with density matrix f:

$$\partial_t N = -i[\Omega, N] - \Gamma_\mathrm{b} \circ (N - N^{(0)}) - \tfrac{1}{2}\{V_x \partial_x, N\}, \tag{2}$$

$$\partial_t f = -i[H_e, f] - \Gamma_\mathrm{e} \circ (f - f^{(0)}) - \tfrac{1}{2}\{v_{e,x} \partial_x, f\} + \mathcal{C}_{e\leftrightarrow b}, \tag{3}$$

where Γ_{b} and Γ_{e} are diagonal damping superoperators, and $\mathcal{C}_{e\leftrightarrow b}$ encodes electron–swirl coupling (Born–Markov, rotating-wave):

$$\mathcal{C}_{e\leftrightarrow b} \equiv -\frac{i}{\hbar}[M, f \otimes N]_{\mathrm{RWA}} \,. \tag{4}$$

2.1 Linear response to a static gradient

Assume a small, uniform $\partial_x T$ and time-independent steady state. Linearize about equilibrium $N^{(0)}(T)$, $f^{(0)}(T)$ using $N = N^{(0)} + N^{(1)}$, $f = f^{(0)} + f^{(1)}$ and retain terms $\mathcal{O}(\partial_x T)$. For a *two-branch* bosonic subspace s, s' near-degenerate by $\delta = \Omega_{s'} - \Omega_s$ and a single electronic transition Δ, the off-diagonal coherence $N^{(1)}_{ss'}$ solves

$$\Big[i\delta + \tfrac{1}{2}(\gamma_s + \gamma_{s'})\Big] N^{(1)}_{ss'} \;=\; -\frac{1}{2} V^{(x)}_{ss'}\, \partial_x N^{(0)}_{\mathrm{pop}}(\Omega) \;-\; \frac{i}{\hbar}\, \Xi_{ss'} \,, \tag{5}$$

with γ the linewidths and $\Xi_{ss'}$ the electron-induced source from $\mathcal{C}_{e\leftrightarrow b}$ (proportional to the coupling vertex M and to $f^{(1)}$). The population correction obeys

$$(\gamma_s)\, N^{(1)}_{ss} + V^{(x)}_{ss}\, \partial_x N^{(0)}_{ss} + 2\,\mathrm{Im}\big(V^{(x)}_{ss'}\, N^{(1)}_{s's}\big) = S^{(e)}_s \,, \tag{6}$$

where $S^{(e)}_s$ collects electron-related terms.

2.2 Closed form for the coherence contribution to κ

The heat current density for bosonic modes is $J_x = \mathrm{Tr}\left[\{V_x, N\}\,\Omega/2\right]$ [3,6]. Using Eqs. (5)–(6) and eliminating $f^{(1)}$ in the weak-coupling (Born) limit yields the *coherence* part of the 1D thermal conductivity

$$\boxed{\kappa^{(\mathrm{C})}_{\mathrm{1D}} \;=\; \sum_q \sum_{s\neq s'} \frac{(\Omega_s + \Omega_{s'})\, \Gamma_{ss'}\, |V^{(x)}_{ss'}|^2}{4\delta^2 + \Gamma^2_{ss'}} \left(-\frac{\partial n_B}{\partial T}\right) \;+\; \mathcal{O}(|M|^2) \,,} \tag{7}$$

where $\Gamma_{ss'} = \frac{1}{2}(\gamma_s + \gamma_{s'})$ and n_B is the Bose function. Equation (7) reduces to Peierls (no off-diagonals) and to Allen–Feldman (flat bands, $V_{ss} \to 0$) in the appropriate limits [1–3]. The $\mathcal{O}(|M|^2)$ corrections add an *electron-assisted* channel with the same Lorentzian denominator.

3 1D slab: temperature field and $\Delta\kappa/\kappa$

Consider a bar of length L, cross-section A, thermal conductivity $\kappa = \kappa^{(\mathrm{P})} + \kappa^{(\mathrm{C})}$. A steady heater power P at $x = 0$ with heat sink at $x = L$ gives $\partial_x T = -P/(\kappa A)$ and

$$\Delta T \equiv T(0) - T(L) = \frac{P\,L}{\kappa A} \,. \tag{8}$$

A small VAM-induced change $\Delta\kappa$ results in

$$\boxed{\Delta(\Delta T) \approx -\frac{\Delta\kappa}{\kappa}\, \Delta T \,,} \tag{9}$$

valid for $|\Delta\kappa| \ll \kappa$. Combining (7) and (9) links *measured* temperature differences to microscopic parameters $\delta, \Gamma, V_{ss'}$.

4 Quantitative benchmarks with materials

We propose concrete specimens and give order-of-magnitude signals using Eq. (9).

(B1) Borosilicate glass bar

$L = 50\,\mathrm{mm}$, $A = 1 \times 10^{-4}\,\mathrm{m}^2$ ($10\,\mathrm{mm}\times 10\,\mathrm{mm}$), $\kappa \approx 1.1\,\mathrm{W\,m^{-1}\,K^{-1}}$. Choose $P = 20\,\mathrm{mW}$: baseline $\Delta T \approx PL/(\kappa A) \approx 9\,\mathrm{K}$. If engineered degeneracy gives $\Delta\kappa/\kappa = -2\,\%$ from (7), then $\Delta(\Delta T) \approx +0.18\,\mathrm{K}$. This exceeds typical IR-camera NETD ($\sim 30\,\mathrm{mK}$) by $> 5\times$.

(B2) PMMA bar (low-κ polymer)

$\kappa \approx 0.19\,\mathrm{W\,m^{-1}\,K^{-1}}$, keep $L = 50\,\mathrm{mm}$, $A = 1\times 10^{-4}\,\mathrm{m}^2$, use $P = 2\,\mathrm{mW}$ to avoid overheating: baseline $\Delta T \approx 5.3\,\mathrm{K}$. A conservative $\Delta\kappa/\kappa = -1\,\%$ yields $53\,\mathrm{mK}$ shift—still above NETD.

(B3) Forward/backward nonreciprocity

Drive a 3-phase Rodin coil with phase sequence $\pm(0,\,120^\circ,\,240^\circ)$ to bias chirality. Expect

$$\big[\Delta\kappa\big]_{\rightarrow} - \big[\Delta\kappa\big]_{\leftarrow} \equiv \Delta\kappa_{\mathrm{asym}} \sim \eta_\chi \,\frac{\Gamma\,\Delta V_{ss'}^2}{4\delta^2 + \Gamma^2}\,, \qquad 0 < \eta_\chi < 1\,. \tag{10}$$

Taking $\Delta\kappa_{\mathrm{asym}}/\kappa \sim 0.5\,\%$ implies a measurable $\Delta(\Delta T) \sim 25\,\mathrm{mK}$ for (B1).

5 Device recipes

Thermal bar (B1/B2). Bar glued on an Al nitride heat sink at $x = L$. Heater: $100\,\Omega$ thin-film resistor at $x = 0$, four-wire calibrated. Enclosure to suppress convection (foam + thin IR window). IR camera or thermistors along x. Coil: 3-phase, $N \sim 200$ turns/phase, $f \in [20\,\mathrm{kHz}, 100\,\mathrm{kHz}]$, current $\leq 0.5\,\mathrm{A}$, duty-cycled to limit Joule heating.

Electronics analog (LCR). Two LCR tanks at $1\,\mathrm{MHz}$, $Q \sim 100$ ($\kappa = \omega/2Q \approx 3.1 \times 10^4\,\mathrm{s^{-1}}$). With stored energy $E \sim 0.5\,\mathrm{nJ}$, instantaneous dissipated power $P_{\mathrm{bath}} = \kappa E \sim 16\,\mu\mathrm{W}$. Adding a near-degenerate second tank elevates the early-time peak by the Lorentzian factor in (7).

Quantum hybrid (SAW/MEMS). Piezo substrate (128° Y-cut $\mathrm{LiNbO_3}$). IDT pair for a $3\,\mathrm{GHz}$ SAW mode; superconducting qubit capacitively coupled [10,11]. Pattern shallow quasi-periodic notches to enhance $V_{ss'}^{(x)}$ and tune δ.

6 Error and noise budget

- **Thermometry:** IR camera NETD $30--50$mK; thermistor readout noise $<10\,\mathrm{mK}$ with $1\,\mathrm{s}$ averaging.
- **Power calibration:** $<1\,\%$ with four-wire measurement.

- **Radiation/convection:** Within enclosure, systematic drift $\lesssim 0.05\,\mathrm{K}$ over $10\,\mathrm{min}$. Acquire forward/backward sweeps in quick succession to common-mode cancel.
- **Contact resistance:** Use indium foil at heater/bar/sink interfaces; verify with repeated mounting.

Expected signals $(50 -- 200 mK)$ clear the combined noise by factors $\gtrsim 3$ for (B1/B2).

7 Falsifiability criteria

The electron–swirl interpretation is *falsified* if any of the following hold under the stated drive:

1. **No Lorentzian detuning:** $\Delta\kappa(\delta)$ lacks the $(4\delta^2 + \Gamma^2)^{-1}$ peak predicted by (7) at fixed current.
2. **No chirality asymmetry:** $|\Delta\kappa_{\mathrm{asym}}/\kappa| < 3\sigma$ with σ the thermal readout error; target sensitivity $\leq 0.1\,\%$ via averaging.
3. **Parameter scaling mismatch:** Signal does not scale as $|V_{ss'}^{(x)}|^2$ (via coil current squared) nor with Γ (via controlled disorder).

8 Connection to quantum information

In the Jaynes–Cummings limit [7], the same vertices M and $V_{ss'}$ that maximize $\kappa^{(\mathrm{C})}$ also maximize state transfer between electron and swirl modes. In a hybrid device, one can exploit the *coherence peak* (small δ, moderate Γ) to route heat out of the qubit while preserving its phase, akin to engineered reservoirs [9, 10].

9 Conclusions

We provided closed-form transport expressions, concrete device geometries, quantitative signals, a noise budget, and falsifiability criteria. These enable immediate lab tests that adjudicate the presence of coherence-mediated electron–swirl transport in VAM.

Acknowledgments

The author thanks the classical foundations of vortex hydrodynamics and unified transport [1–4] for inspiration.

References

[1] R. Peierls, Ann. Phys. **395**, 1055 (1929).

[2] P. B. Allen and J. L. Feldman, Phys. Rev. B **48**, 12581 (1993).

[3] M. Simoncelli, N. Marzari, and F. Mauri, Nat. Phys. **18**, 1180 (2022); arXiv:1901.01964.

[4] E. Madelung, Z. Physik **40**, 322 (1927).

[5] A. K. Pati and S. L. Braunstein, Phys. Lett. A **268**, 241 (2000).

[6] R. J. Hardy, Phys. Rev. **132**, 168 (1963).

[7] E. T. Jaynes and F. W. Cummings, Proc. IEEE **51**, 89 (1963).

[8] G. Lindblad, Commun. Math. Phys. **48**, 119 (1976).

[9] H.-P. Breuer and F. Petruccione, *The Theory of Open Quantum Systems*, Oxford (2002).

[10] M. Aspelmeyer, T. J. Kippenberg, and F. Marquardt, Rev. Mod. Phys. **86**, 1391 (2014).

[11] R. Manenti *et al.*, Nat. Commun. **8**, 975 (2017).

[12] D. G. Cahill *et al.*, J. Appl. Phys. **93**, 793 (2003).