

The Dutch Vacuum Landscape

Where the Net Theory Meets the Groups That Measure and Switch the Vacuum in the Netherlands

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Abstract

Four Dutch research lines work on the quantity that the Vacuum.Net theory calls passage through a mesh. None of them calls it that. In Groningen the Casimir force between surfaces is measured and switched between a high and a low state by changing the material in place. In Eindhoven and at AMOLF the field in a cavity is used to change the properties of matter without illuminating it. In Amsterdam a fluctuation force is used that grows as a medium approaches its critical point. In Delft free-standing membranes are measured in continuous thermal motion. This article sets each line beside the net theory, states where the two formalisms meet and where they differ, and names the people, with their addresses, whose running work is closest to the net generator of Part Five. Two findings stand out. The Groningen group already does in-place what the net calls setting δ , and reports a force contrast of 20 to 25 per cent. And no Dutch group works on the open side of the mesh — the conversion of what the mesh closes into current — which is where the whole remaining distance of the net generator lies.

1. The quantity in question

The image is a fishnet in water. Its strands run everywhere and are always under tension. Where strands wind around each other, knots appear: matter. Between strands lie meshes: openings with a shape and a size. A winding persists only if it returns in phase inside its mesh. What does not fit does not stay.

The local tension of the net is χ . Constants are state functions of χ . The local density deviation δ is tied to χ by the bridge $\delta = k \cdot \chi$. The effective coupling follows the constitutive law

$$g_{\text{eff}} = \bar{g}(1 + \gamma\delta),$$

so the sensitivity of the coupling to a density shift is

$$d \ln g_{\text{eff}} / d\delta = \gamma = 1/\varepsilon,$$

where ε is the distance of the net to its critical point. With $\gamma = 2\pi$, $\varepsilon = 0.159$: a shift of one per cent in local density gives 6.3 per cent in coupling.

A mesh of one natural unit of space, 45.6 nm, closes a definite amount. The reverse step to Casimir's count gives

$$E = \pi^2 \hbar c / (720 L) = 9.5 \times 10^{-21} \text{ J at } L = 45.6 \text{ nm}.$$

Passed once per natural unit of time, 1.52×10^{-16} s, that is 6.3×10^{-5} W per mesh. Of what one measured mesh closes, Moddel's palladium film delivers 2.4×10^{-9} as current. That fraction is the open-side coupling, and it is the one number the design still needs.

Four quantities therefore matter: the size of the mesh, the asymmetry between its two walls, the distance of the medium to its critical point, and the coupling on the open side. The Dutch landscape works on the first three. The fourth is untouched here.

2. Groningen: switching the force in place

Prof. George Palasantzas holds the chair of Surface Interactions and Nanostructures at the Zernike Institute for Advanced Materials, University of Groningen. He chaired the European Casimir network of more than sixty groups. His programme has two parts. The first is the influence of surface roughness and optical material properties on the Casimir force, and through it on the actuation dynamics of MEMS and NEMS. The second is the control of the force by reversible amorphous-to-crystalline phase transitions in phase-change materials, so that the force can be switched in place between a high and a low state without any change of composition.

That second part is the closest thing in the Netherlands to the operation the net calls setting δ . The reported contrast is an increase of 20 to 25 per cent in the Casimir force between gold and AIST ($\text{Ag}_5\text{In}_5\text{Sb}_{60}\text{Te}_{30}$) on crystallisation. In the group's own account, about half of that contrast comes from free-carrier absorption in the infrared and about half from resonance bonding in the visible, which is unique to the crystalline phase.

Where the two formalisms meet. Both describe a wall whose dielectric response decides what the mesh returns, and both treat that response as settable rather than fixed. Both work in the same size range: the force matters below roughly 200 nm, and the net's unit of space is 45.6 nm.

Where they differ. The group computes the force with Lifshitz theory from the measured dielectric function of each material. The net computes passage from the ratio of space to time, $1/S$, and takes the natural unit of space from the Rydberg frequency and c . These are two notations for the same configuration. The Lifshitz route is calibrated and detailed; the net route is short and gives the mesh size without fitting. A translation between them is possible in principle and has not been written.

What is useful for the net. Three things. The measured contrast is a measured δ -setting, and its size, 20 to 25 per cent, is directly comparable with $\gamma\delta$ in the constitutive law. The group's finding that protective capping layers must be only a few nanometres thick to preserve the contrast is a statement about the depth over which a wall counts. And their observation that surface roughness strongly increases the force below 100 nm is a statement about what a non-flat wall does to closure.

Funding is current. A 2022 NWO Open Technology Programme grant covers repulsive Casimir forces from topological insulators toward device actuation. A 2022 NWO Open Competition ENW-M grant covers Casimir force control by reversible amorphous-crystalline phase transitions. A 2025 publication reports crystallisation and oxidation effects on Casimir forces from phase-change $\text{Ge}_2\text{Sb}_2\text{Te}_5$ thin films.

3. Twente: the theory beside the Groningen measurements

Dr Vitaly Svetovoy worked at the MESA+ Institute for Nanotechnology, University of Twente, and is the theoretical partner on much of the Groningen work. He is co-author of the AIST force-

contrast papers and of the roughness correction to the Casimir force beyond perturbation theory, written with Broer, Palasantzas and Knoester. The roughness work addresses exactly the case where surface roughness becomes comparable with the separation between the bodies — the regime of a mesh at one unit of space.

Relevance to the net. The question of what a rough wall returns is the question of what fraction of a winding comes back in phase. This is the nearest existing treatment of the closed-wall fraction.

4. Eindhoven and AMOLF: the field as a handle on matter

Prof. Jaime Gómez Rivas holds a chair at Eindhoven University of Technology and is affiliated with DIFFER. He pioneered the use of metal nanoparticle arrays for strong light-matter coupling, and his group studies how molecular electronic transitions interact with electromagnetic fields to form hybrid light-matter states. They have demonstrated polariton lasing and condensation at room temperature. He organised the Eindhoven workshops on strong coupling with organic molecules, which drew about 125 researchers from Europe, Japan and the United States. His current focus includes bound states in the continuum: optical modes without loss, in the visible and at terahertz frequencies.

The field this work belongs to states its own premise plainly. Its founding paper is titled "Modifying Chemical Landscapes by Coupling to Vacuum Fields." Reaction rates, ionic conductivity and molecular polarisability have been reported to change under coupling to the field of a cavity, with no illumination. In the terms of the net: a mesh is imposed, and what is inside it behaves differently because a different set of windings now closes there.

Dr Said Rodriguez leads the Interacting Photons group at the Center for Nanophotonics, AMOLF, Amsterdam. He took his doctorate with Gómez Rivas and now works with open-access tunable microcavities, where the mirror separation is a continuously adjustable parameter. His group studies what emerges from the interplay of optical nonlinearity and noise. Recent output includes the stochastic thermodynamics of a linear optical cavity driven on resonance, photon superfluidity through dissipation, memory-induced excitability in optical cavities, and a master's project on modifying electrical conductivity with optical cavities.

Where the two formalisms meet. Both treat the cavity as something that selects. Both treat its size as the setting. The open-access tunable cavity is, in net terms, a mesh whose size L is a control variable — the hold of Part Five without the hold.

Where they differ. This work stays inside quantum electrodynamics and counts modes and coupling strengths. The net does not count modes; it asks which windings return in phase. The two give the same answer for a symmetric cavity. They part company on an asymmetric one, where the net predicts passage and QED predicts none.

What is useful for the net. Four things. Open-access cavities give a working form of the hold. Bound states in the continuum are, in net language, closure without loss. The stochastic thermodynamics work addresses the exact objection a reviewer raises against the net generator. And "modifying electrical conductivity with optical cavities" is the only Dutch work found that touches the open side of the mesh at all.

5. Amsterdam: the lever near the critical point

Prof. Peter Schall holds the chair of Soft Condensed Matter Physics at the Institute of Physics, University of Amsterdam. He works with the critical Casimir force: the thermodynamic analogue of the quantum Casimir effect, arising when two surfaces sit in a binary liquid mixture near its critical point and the confinement of concentration fluctuations produces an attraction. The correlation length depends on temperature, so the force is tunable by temperature alone. He uses it to drive colloidal phase transitions, following a colloidal gas freezing into a liquid and a liquid into a solid, in three dimensions and real time. The work extends to critical Casimir torques, to patchy colloidal building blocks, and to microgravity experiments aboard the International Space Station.

Where the two formalisms meet. This is the one Dutch line that works where the net theory says the lever is. The constitutive law gives $d \ln g_{\text{eff}} / d\delta = 1/\varepsilon$. Schall's system is an experimental realisation of a medium whose ε is set by a dial: move the temperature toward the critical point, and the interaction grows. The underlying claim — that confinement of fluctuations near a critical point produces a force that grows as the distance to that point shrinks — is the same claim in a different medium.

Where they differ. The critical Casimir force arises from concentration fluctuations in a liquid mixture; the net's tension is not a concentration. The net reads them as the same winding at a different depth, by N5. That reading is a correspondence, not a derivation.

What is useful for the net. The temperature control of the correlation length is a direct measurement of the lever $1/\varepsilon$ in a medium where ε can be set. If the net's claim that sensitivity equals inverse distance to the critical point is right, it should hold in this medium too, and it is measurable there.

6. Delft: membranes in continuous motion

Prof. Peter Steeneken is full professor at the Department of Precision and Microsystems Engineering, Delft University of Technology, chairing the Dynamics of Micro and Nanosystems group, with a part-time affiliation to the Kavli Institute of Nanoscience. He leads the sensors work package of the Graphene Flagship. His group measures suspended graphene and MoS₂ membranes: resonance, thermal motion, nonlinear dynamics, pressure and gas sensing, squeeze-film effects. The doctoral thesis "Dynamics of Interacting Graphene Membranes" was supervised by Steeneken and Van der Zant.

This is the Dutch group that holds the material Thibado uses. Thibado's result is that a free-standing graphene membrane moves continuously at room temperature, that its motion is not classical Brownian motion but shows Lévy flights with curvature inversion, and that this motion can drive a current through a circuit of two opposed diodes.

Relevance to the net. In net terms a rippling membrane with two opposed diodes is a mesh with one open passage. The Delft group has the membranes and the measurement methods; it does not work on energy harvesting. The capability is there and the question is not asked.

7. What the comparison yields

The same object, two notations. The Casimir force and passage through a mesh describe the same configuration: a gap between two walls, below a few hundred nanometres, where what fits decides what happens. Lifshitz theory computes it from measured dielectric functions. The net computes it from the ratio of space to time. Lifshitz is calibrated; the net gives the mesh size, 45.6 nm, without

fitting. Neither has been translated into the other, and that translation is the single most useful piece of work available here, because it would let every existing measurement be read in both.

Setting the state is already routine. The objection that one cannot set the local state of a medium is answered by three Dutch programmes. Palasantzas switches the force in place by a phase transition. Rodriguez tunes a cavity continuously. Schall moves a medium toward and away from its critical point with temperature. What differs is only the claim about what is being set.

The lever is measurable where ϵ is settable. The claim that sensitivity equals $1/\epsilon$ is testable in Schall's medium, where ϵ is a temperature setting, more easily than in a solid.

The open side is empty. Of the four quantities the net generator needs, three have Dutch programmes behind them. The fourth — how much of what the mesh closes leaves as current — has none. That is where nine orders of margin sit, and it is unworked here.

One asymmetry of framing. All four Dutch lines treat the vacuum field as a boundary condition on something else: a force between bodies, a shift in a molecular level, an attraction between colloids. The net treats it as the one strand, and the bodies as windings in it. The measurements do not distinguish the two readings. The difference shows only in what one asks next. Within the first framing, an asymmetric mesh is not a natural question. Within the second, it is the only question.

8. The contact list

Addresses marked **verified** were found on an institutional page, a vacancy text, or a corresponding author line. Addresses marked **inferred** follow the institution's standard pattern and have not been confirmed. Addresses marked **dated** come from a source more than ten years old.

Closest to the mesh itself

Who	Where	Address	Why
Prof. George Palasa	Zernike Institute for Advanced Materials, University of	g.palasantzas@rug.nl — verified	Switches the Casimir force in place by phase transition; measured contrast 20–25%; roughness below 100 nm; two current NWO
Dr Vitaly Svetov	MESA+ Institute for Nanotechnology, University of Twente	v.b.svetovoy@utwente.nl — inferred ; affiliation may have	Theory beside the Groningen measurements; roughness correction beyond perturbation theory
Dr A. Atul	Zernike Institute, University of	unknown	Co-author on the 2025 phase-change Casimir paper; reachable through

Closest to the cavity as a handle on matter

Who	Where	Address	Why
Dr Said R. K.	Interacting Photons, AMOLF,	s.rodriguez@amolf.nl	Open-access tunable microcavities; stochastic thermodynamics of a driven cavity; work on
Prof. Jaime	Eindhoven University of	J.gomez.rivas@tue.nl —	Strong light-matter coupling; the field that modifies matter through vacuum fields; bound states in the
Dr Giel Keijsers	formerly AMOLF and Utrecht	unknown	Doctorate November 2025 on strong light-matter interactions in driven open-access cavities; reachable
Prof. Allard	Utrecht University	a.p.mosk@uu.nl —	Co-supervisor on the current AMOLF–Utrecht doctoral project on phase transitions for optical

Closest to the lever near the critical point

Who	Where	Address	Why
Prof. Peter	Institute of Physics, University of	p.schall@uva.nl —	Critical Casimir forces with temperature-settable correlation length; the only Dutch system where ϵ is

Closest to the membrane

Who	Where	Address	Why
Prof. Peter	Precision and Microsystems Engineering, Delft	p.g.steeneken@tudelft.nl —	Suspended graphene and MoS ₂ membranes, thermal motion, nonlinear dynamics; holds
PME Secretariat	Delft University of Technology	secre-pme-me@tudelft.nl — verified	Departmental route

Measurement of the force itself

Who	Where	Address	Why
Prof. Davide	Department of Physics and Astronomy, VU	iannuzzi@few.vu.nl — dated , from a 2010	Measured the Casimir force with ferrule-top and fibre-top sensors; halved the force by replacing gold with indium tin oxide; whether this line is still

Outside the Netherlands, for completeness

Who	Where	Why
Prof. Garret Model	University of Colorado Boulder	The one measured mesh: optical-cavity-induced current, 2021. The zero of the open-side coupling
Prof. Paul Thibado	University of Arkansas	Fluctuation-induced current from free-standing graphene; the rippling membrane with two opposed diodes

9. Where each contact leads

The four lines are not interchangeable, and a single approach to all of them would be the wrong move. Each has one question it is in a position to answer.

Groningen can answer what a periodic wall returns compared with a mirror. They have the thin-film line, the force measurement, the phase-change materials and the roughness treatment. The question is narrow and inside their existing programme: does a wall that repeats at a fixed period return more than a flat mirror of the same metal, and how does that depend on the number of periods.

AMOLF can answer what happens when the two walls of a tunable cavity are made unlike each other. Their cavity is open-access and continuously adjustable, and their group already measures a driven cavity thermodynamically. Asymmetry is a change of sample, not of apparatus.

Amsterdam can answer whether sensitivity equals inverse distance to the critical point, in the one medium where that distance is a temperature setting.

Delft can answer what a suspended membrane does when the circuit behind it is asymmetric. They hold the membranes and the methods.

Eindhoven sits in the field whose premise is closest to the net's: that the field in a cavity changes what matter does, without illumination. That is the conceptual meeting point rather than a specific measurement.

10. What this article does not establish

No Dutch group was found working on the conversion of vacuum fluctuations into useful current. The four lines above work on the force, the field, the critical point and the membrane. The step from any of these to a current is taken nowhere in this country.

Three theory communities were not searched: Radboud (graphene theory), Leiden (cavity QED) and the Utrecht theory groups. A Dutch group working on the dynamical Casimir effect or on quantum friction was not found, and absence of evidence here is not evidence of absence.

Five of the eleven Dutch addresses above are inferred or dated rather than verified. Each can be confirmed from the institution's own staff page.

Annotated references

The net

Konstapel, J. (2026a). *The Vacuum.Net Theory: Foundational Paper*, sixth edition. Constable Research, Leiden. *Why read?* The five axioms and theorems T1 to T7, and the five-status convention used throughout this article.

Konstapel, J. (2026b). *Applied Vacuum Theory: Setting the State of the Net*, fourth edition. Constable Research, Leiden, 25 September 2026. *Why read?* The control variables, the constitutive law, the identity $\gamma = 1/\epsilon$, and the open step. Section 5 is the stiff-versus-soft calculation this article uses.

Konstapel, J. (2026c). *Applied Vacuum Theory, Part Five: The Net Generator*, second edition. Constable Research, Leiden, 27 September 2026. *Why read?* The mesh at one natural unit, the reverse step to Casimir's count, and the finding that the remaining distance lies on the open side. *Reading advice:* the abstract and Section 3.

Konstapel, J. (2026d). *Builders of the Net*. Constable Research, Leiden, 24 September 2026. *Why read?* Six builders read as meshes, across fourteen orders of magnitude.

Groningen and Twente

Torricelli, G., van Zwol, P. J., Shpak, O., Binns, C., Palasantzas, G., Kooi, B. J., Svetovoy, V. B., and Wuttig, M. (2010). "Switching Casimir forces with phase-change materials." *Physical Review A* 82, 010101(R). *Why read?* The measurement that a Casimir force can be switched in place by a phase transition. This is the nearest existing realisation of setting δ .

Torricelli, G., Pirozhenko, I., Thornton, S., Lambrecht, A., and Binns, C., with Palasantzas and Svetovoy (2012). "Casimir force contrast between amorphous and crystalline phases of AIST." *Advanced Functional Materials*. *Why read?* The 20 to 25 per cent contrast, split roughly half to free carriers and half to resonance bonding, and the finding that capping layers must be only a few nanometres thick. *Reading advice:* the analysis of where the contrast comes from.

Broer, W., Palasantzas, G., Knoester, J., and Svetovoy, V. B. (2011). "Roughness correction to the Casimir force beyond perturbation theory." *Europhysics Letters* 95, 30001. *Why read?* The case where roughness is comparable with the separation. The nearest treatment of what a non-flat wall returns.

Tajik, F., Sedighi, M., Khorrami, M., Masoudi, A. A., and Palasantzas, G. (2017). "Chaotic behavior in Casimir oscillators: a case study for phase change materials." *Physical Review E* 96, 042215. *Why read?* What happens to a system driven near the force transition. Relevant to the stability of any hold.

Eindhoven and AMOLF

Ebbesen, T. W. (2012). "Modifying chemical landscapes by coupling to vacuum fields." *Angewandte Chemie International Edition* 51, 1592. *Why read?* The founding statement of the field that changes matter with a cavity field and no illumination. The closest existing premise to the net's own.

Bhuyan, R., Mony, J., Kotov, O., Castellanos, G. W., Gómez Rivas, J., Shegai, T. O., and Börjesson, K. (2023). "The rise and current status of polaritonic photochemistry and photophysics." *Chemical Reviews* 123, 10877. *Why read?* The experimental landmarks of the field, with Gómez Rivas as co-author. *Reading advice:* the section on what sets the coupling strength.

Keijsers, G., Geng, Z., Peters, K. J. H., Wouters, M., and Rodriguez, S. R. K. (2023). "Photon superfluidity through dissipation." *Physical Review Letters*. *Why read?* What an open-access tunable cavity can be made to do. The cavity is the adjustable mesh.

Keijsers, G., and Rodriguez, S. R. K. (2025). "Stochastic thermodynamics of a linear optical cavity driven on resonance." *ACS Photonics* 12, 159. *Why read?* The thermodynamic bookkeeping of a driven cavity, written by the group whose apparatus is closest to an adjustable mesh.

Keijsers, G. J. G. (2025). *Strong Light-Matter Interactions in Coherently Driven Open-Access Optical Cavities*. Doctoral thesis, Utrecht University, 4 November 2025. *Why read?* The full account of the tunable open-access cavity as an instrument.

Amsterdam

Nguyen, V. D., Faber, S., Hu, Z., Wegdam, G. H., and Schall, P. (2013). "Controlling colloidal phase transitions with critical Casimir forces." *Nature Communications* 4, 1584. *Why read?* A fluctuation force used as a dial, with the correlation length set by temperature. The experimental form of the lever $1/\epsilon$. *Reading advice:* the measurement of the pair potential from density fluctuations.

Delft

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The measured mesh

Model, G., Weerakkody, A., Doroski, D., and Bartusiak, D. (2021). "Optical-cavity-induced current." *Symmetry* 13, 517. *Why read?* The one measured mesh. The stack, the 1.4 pW, the eight artefact tests and the six-month ageing. It fixes the open-side coupling at 2.4×10^{-9} . *Reading advice:* Table 1 and Figure 4.

Thibado, P. M., Kumar, P., Singh, S., Ruiz-Garcia, M., Lasanta, A., and Bonilla, L. L. (2020). "Fluctuation-induced current from freestanding graphene." *Physical Review E* 102, 042101. *Why read?* A rippling membrane with two opposed diodes: one open passage, measured.

Casimir, H. B. G. (1948). "On the attraction between two perfectly conducting plates." *Proceedings KNAW* 51, 793. *Why read?* The older notation for a two-wall mesh. The reverse step from this count gives the net's energy per mesh.