Peter Catto: "Did I do that?"

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Introduction

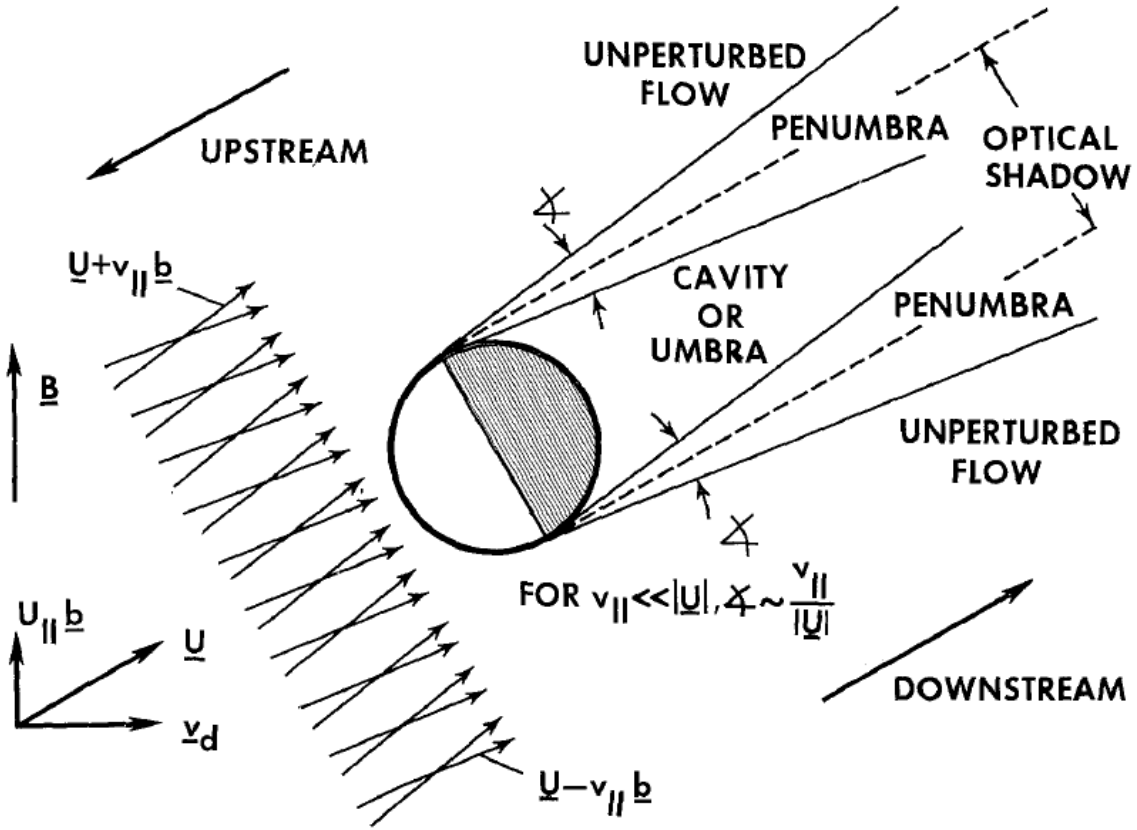
Is Peter a leprechaun?

Research

- Prolific and varied
  - Space plasmas
  - Laser-plasma
  - Drift wave instabilities
  - Turbulence
  - Neoclassical transport
  - Levitated dipole
  - Pedestal
  - Radial electric field

Space physics

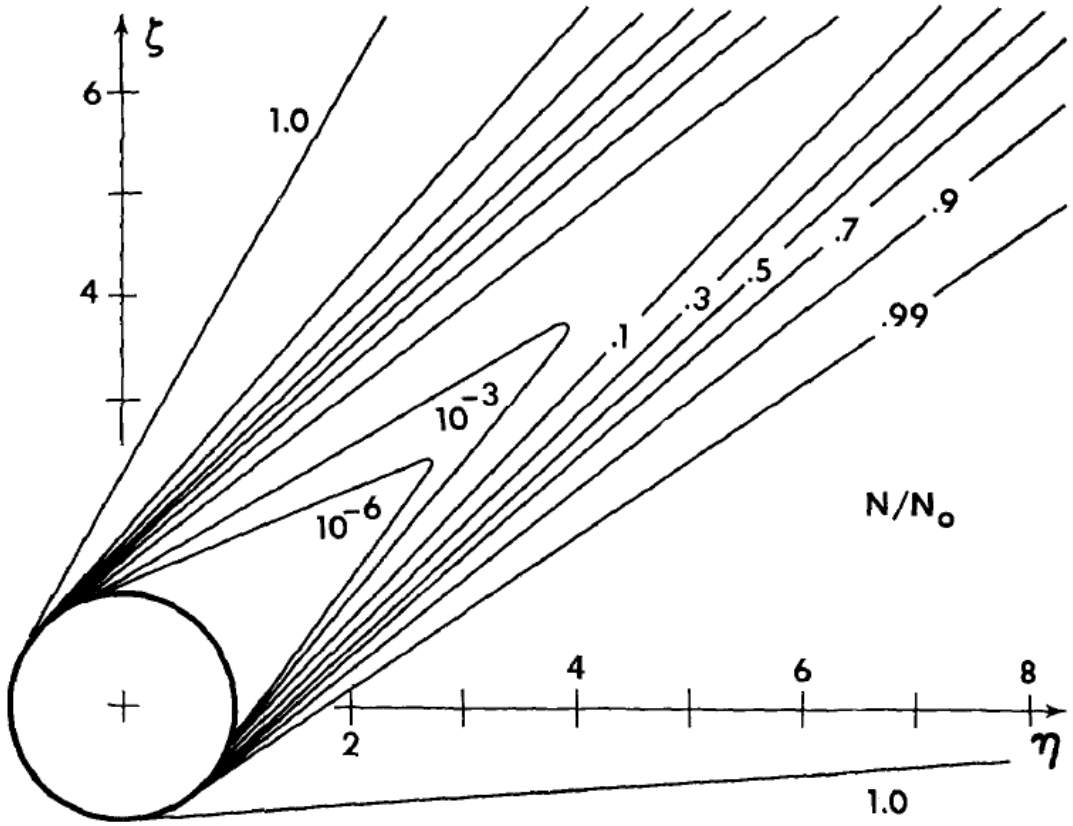
- Interaction of solar wind with the moon



P.J. Catto, "A model for the steady interaction of the solar wind with the moon", *Astrophysics and Space Science* (1974)

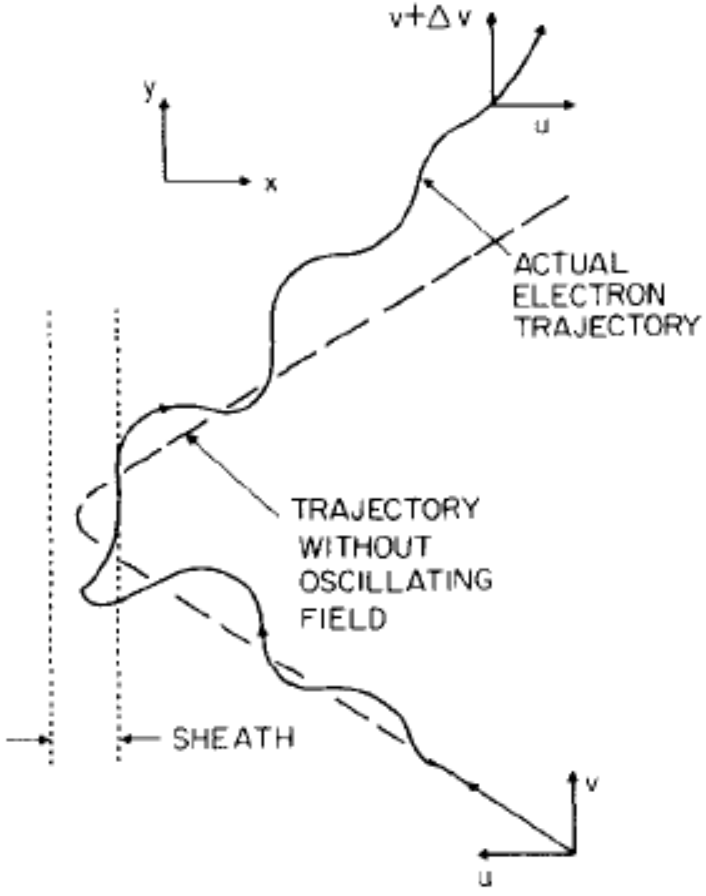
Interaction with the moon

- Fluid equations derived from collisionless Vlasov equation and certain assumption



Laser-plasma interaction

- Mode conversion
  - T. Speziale, P.J. Catto, “Linear wave conversion in an unmagnetized, collisionless plasma”, *PoF* (1977)

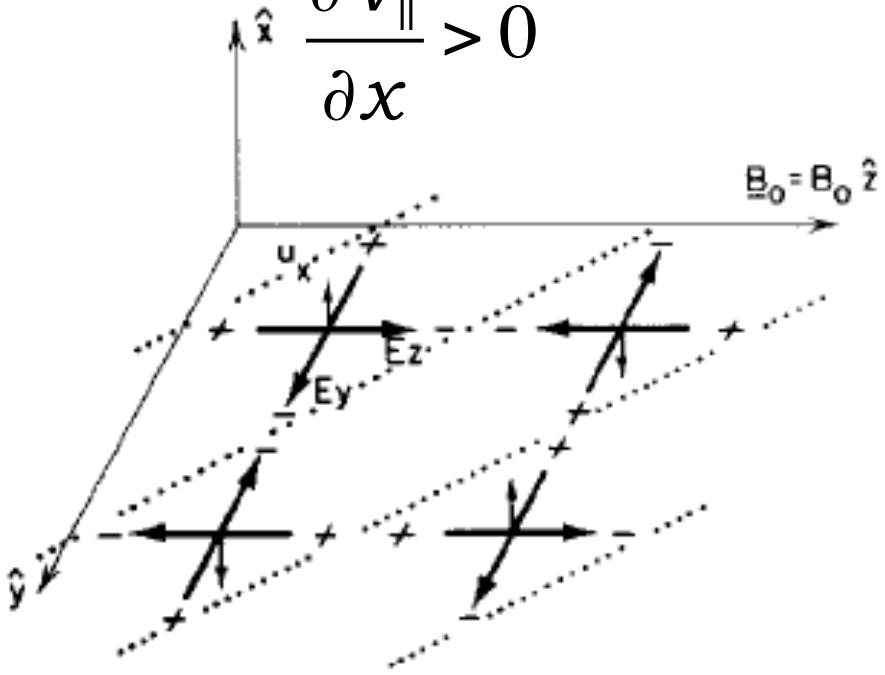


- Radiation absorption
  - P.J. Catto, R.M. More, “Sheath inverse bremsstrahlung in laser produced plasmas”, *PoF* (1977)

Parallel Velocity Gradient instability

- "Did I do that?" Apparently…
  - P.J. Catto, M.N. Rosenbluth, C.S. Liu, "Parallel velocity shear instabilities in an inhomogeneous plasma with a sheared magnetic field", *PoF* (1973)

$$\frac{\partial V_{\parallel}}{\partial x} > 0$$



Debunking the universal instability

- Two PRL submitted at the same time in 1978

Are Drift-Wave Eigenmodes Unstable?

David W. Ross and Swadesh M. Mahajan
Fusion Research Center, The University of Texas at Austin, Austin, Texas 78712
(Received 8 November 1977)

"Absolute Universal Instability" Is Not Universal

K. T. Tsang, P. J. Catto,[a] J. C. Whitson, and Julius Smith
Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830
(Received 22 November 1977)

The roots of an improved analytic eigenvalue equation for the absolute universal or collisionless drift instability in a sheared magnetic field are found numerically and compared with the eigenvalues obtained from a numerical solution of the exact differential equation. The startling result is that both techniques predict stability, no matter how weak the shear or how large the transverse wave number, in contradiction to all previous work. Stability is due primarily to the stabilizing influence of the nonresonant electrons.

First contribution to turbulence

- Nonlinear dispersion relation for turbulence
  - P.J. Catto, “Adiabatic modifications to plasma turbulence theories”, *PoF* (1977)
- Corrects a previous recipe for nonlinear dispersion relation for nonlinear time
- Very interesting paper
  - Separation of scales
  - Proper treatment of fluctuation effects

Neoclassical transport

- Omnigeneity (= no radial magnetic drift = no neoclassical transport)
  - P.J. Catto, R.D. Hazeltine, “Omnigenous equilibria”, *PoF* (1981)
- High flow neoclassical transport
  - P.J. Catto, I.B. Bernstein, M. Tessarotto, “Ion transport in toroidally rotating tokamak plasmas”, *PoF* (1987)
- Radial electric field in Pfirsch-Schluter regime
  - P.J. Catto, A.N. Simakov, “Evaluation of the radial electric field in a collisional tokamak”, *PoP* (2005)

The beginning of gyrokinetics

- The Catto transformation

$$\mathbf{r}, \mathbf{v} \rightarrow \mathbf{R} = \mathbf{r} + \frac{1}{\Omega_s} \mathbf{v} \times \hat{\mathbf{b}}, \varepsilon = \frac{v^2}{2}, \mu = \frac{v_\perp^2}{2B}, \varphi$$

- Published in Plasma Physics 1978

Linearized gyro-kinetics

(*Received* 5 *December* 1977)

Abstract—Finite gyroradius effects are retained in a far simpler manner than previous treatments by transforming to the guiding center variables and gyro-averaging *before* introducing magnetic coordinates.

And more gyrokinetics

- Gyrokinetics with finite β and higher order μ
  - P.J. Catto, W.M. Tang, D.E. Baldwin, “Generalized gyrokinetics”, *Plasma Phys.* (1981)
- High frequency gyrokinetics
  - A visionary? This is cyclo-kinetics…
    - X.S. Lee, J.R. Myra, P.J. Catto, “General frequency gyrokinetics”, *PoF* (1983)
- High flow gyrokinetics
  - I.B. Bernstain, P.J. Catto, “Generalized gyrokinetics”, PoF (1985)

Pedestals

- Large pressure gradient & collisional equilibrium with

$$\frac{\rho_\theta}{L_p} \sim 1$$

  - G. Kagan, P.J. Catto, "Arbitrary poloidal gyroradius effects in tokamak pedestals and transport barriers", *PPCF* (2008)

- Intelligent expansion in $\rho << \rho_\theta$ and $a/R << 1$ to find neoclassical results
  - Trapped particle population diminishes $\Rightarrow$ reduction of neoclassical effects

Peter as an educator

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Some words of wisdom…

Friends come and go, but enemies accumulate

…that couldn't be more wrong