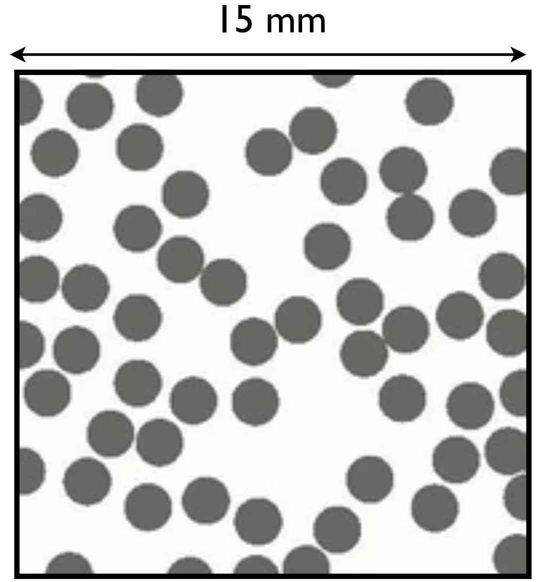
Reminder: last class

Kepler's 3 laws

3-body problem

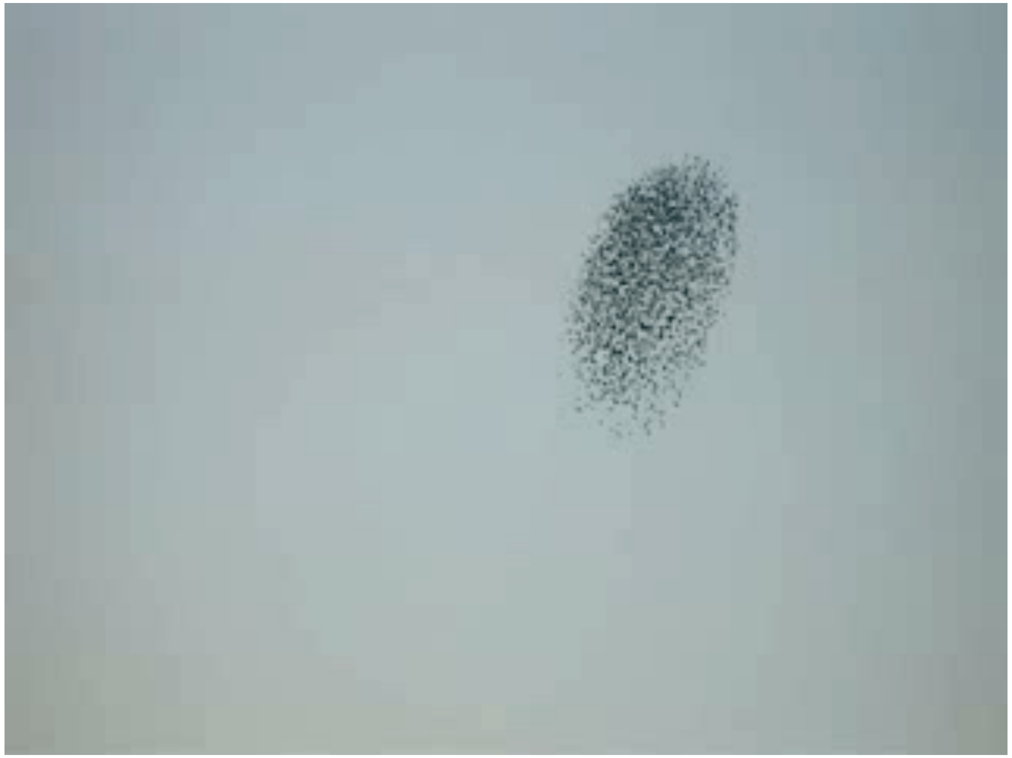


Dilute Fluid

$\phi = 0.34$

Molecular Dynamics Simulations

How do we describe systems with large N of particles?



Falcon attacks a flock of starlings

How do we describe systems with large N of particles?

Swarming:

How do we describe systems with large N of particles?

Traffic flow:

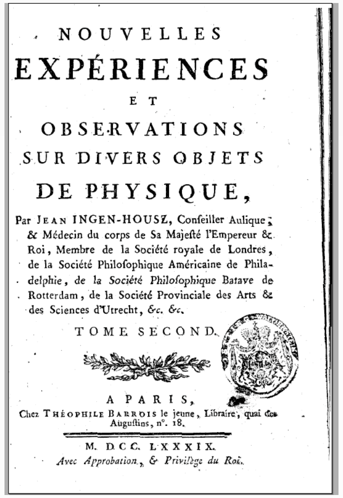
How do we describe systems with large N of particles?

1st example:
Brownian motion

Brownian motion

“Brownian” motion

Jan Ingen-Housz (1730-1799)



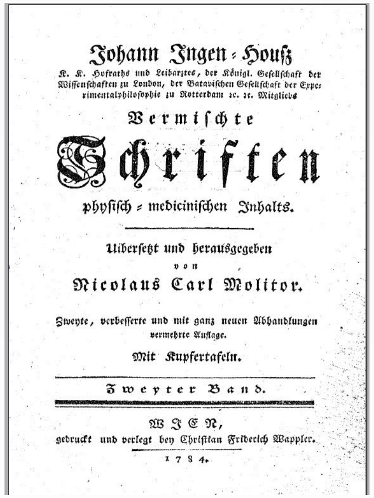
NOUVELLES
EXPÉRIENCES
ET
OBSERVATIONS
SUR DIVERS OBJETS
DE PHYSIQUE,

Par JEAN INGEN-HOUSZ, Conseiller Aulique, & Médecin du corps de Sa Majesté l'Empereur & Roi, Membre de la Société royale de Londres, de la Société Philosophique Américaine de Philadelphie, de la *Société Philosophique* Batave de Rotterdam, de la Société Provinciale des Arts & des Sciences d'Utrecht, *&c. &c.*

TOME SECOND.

A PARIS,
Chez THÉOPHILE BARROIS le jeune, Libraire, quai des Augustins, n°. 18.

M. DCC. LXXXIX.
Avec Approbation, & Privilège du Roi.



Johann Ingen-Housz
K. K. Hofraths und Leibarztes, der Königl. Gesellschaft der Wissenschaften zu London, der Batavischen Gesellschaft der Experimentalphilosophie zu Rotterdam ꝛc. ꝛc. Mitglieds

Vermischte
Schriften
physisch-medicinischen Inhalts.

Uibersetzt und herausgegeben
von
Nicolaus Carl Molitor.

Zweyte, verbesserte und mit ganz neuen Abhandlungen vermehrte Auflage.

Mit Kupfertafeln.

Zweyter Band.

WIEN,
gedruckt und verlegt bey Christian Friderich Wappler.
1784.

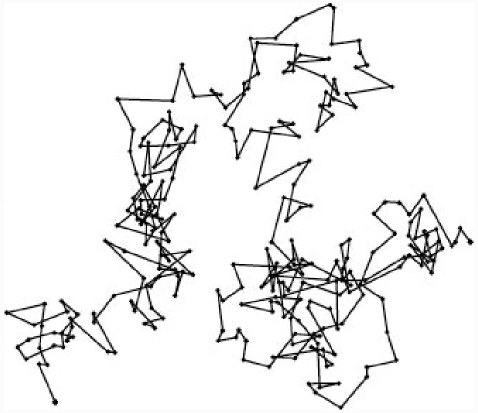
1784/1785:

über betrügen könnte, darf man nur in den Brennpunct
eines Mikroskops einen Tropfen Weingeist sammt etwas
gestoßener Kohle setzen; man wird diese Körperchen in
einer verwirrten beständigen und heftigen Bewegung er-
blicken, als wenn es Thierchen wären, die sich reissend
unter einander fortbewegen.

http://www.physik.uni-augsburg.de/theo1/hanggi/History/BM-History.html

Robert Brown (1773-1858)

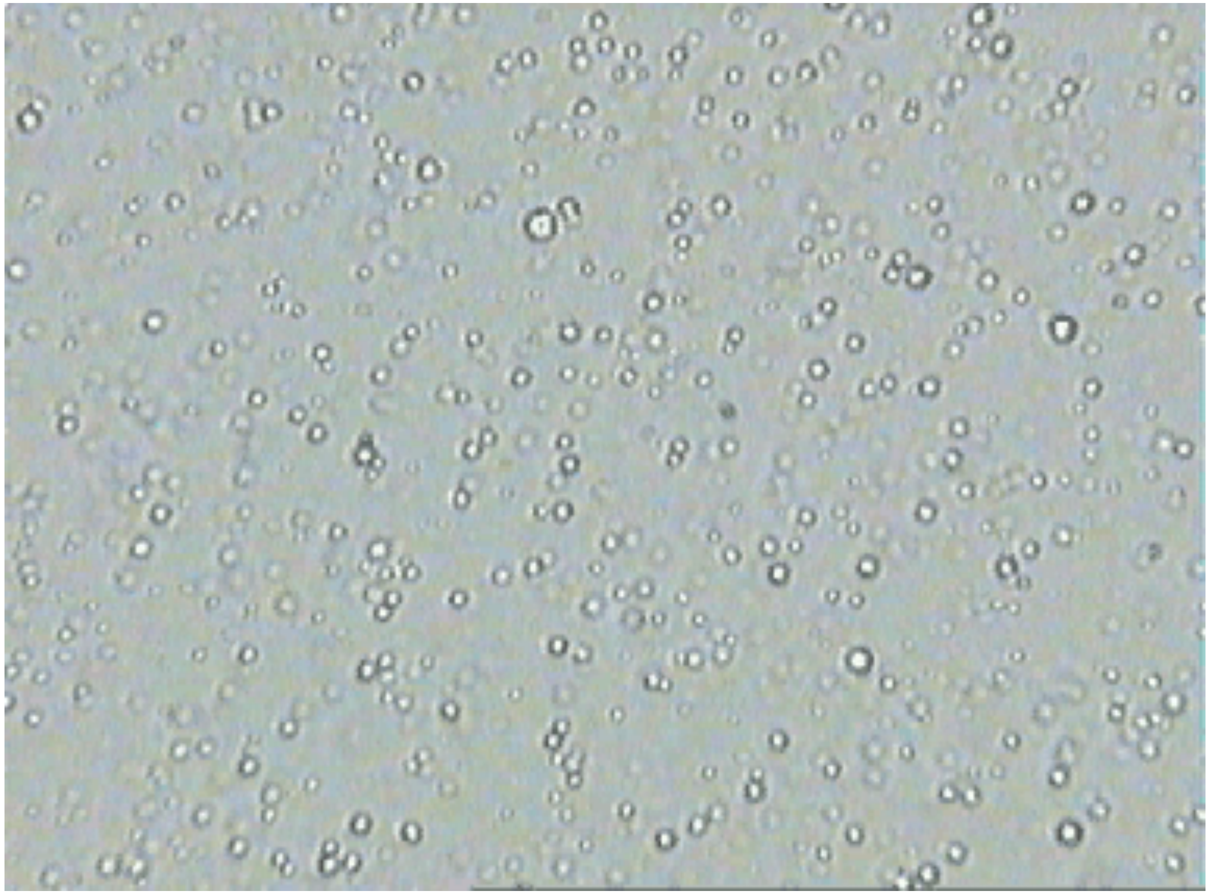
Linnean Society (London)



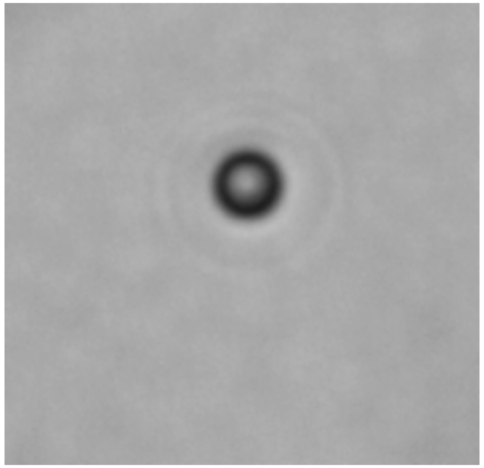
1827: irregular motion of pollen in fluid

http://www.brianjford.com/wbbrownc.htm

Brownian motion

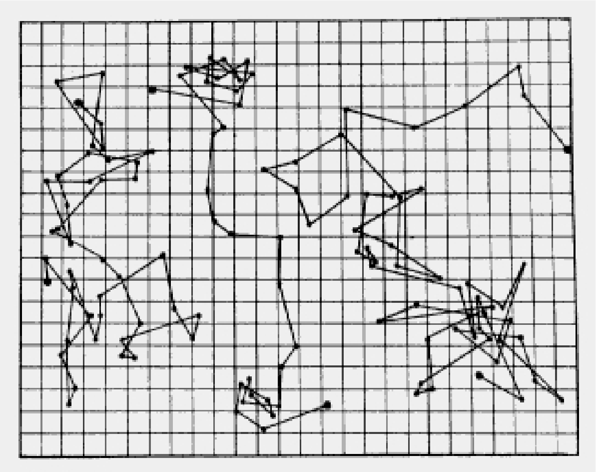


David Walker



Mark Haw

Jean Baptiste Perrin (1870-1942, Nobel prize 1926)



Mouvement brownien et réalité moléculaire, Annales de chimie et de physique VIII 18, 5-114 (1909)

- colloidal particles of radius 0.53μm
- successive positions every 30 seconds joined by straight line segments
- mesh size is 3.2μm

Les Atomes, Paris, Alcan (1913)

experimental evidence for
atomistic structure of matter

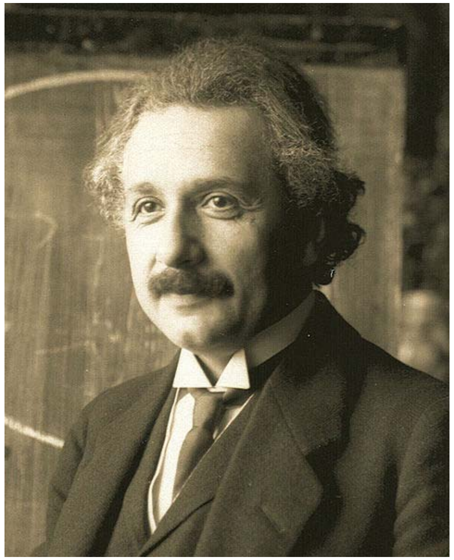
W. Sutherland (1858-1911)

Source: www.theage.com.au

$$D = \frac{RT}{6\pi\eta a C}$$

Phil. Mag. **9**, 781 (1905)

A. Einstein (1879-1955)



Source: wikipedia.org

$$\langle x^2(t) \rangle = 2Dt$$

$$D = \frac{RT}{N}\frac{1}{6\pi k P}$$

Ann. Phys. **17**, 549 (1905)

M. Smoluchowski
(1872-1917)

Source: wikipedia.org

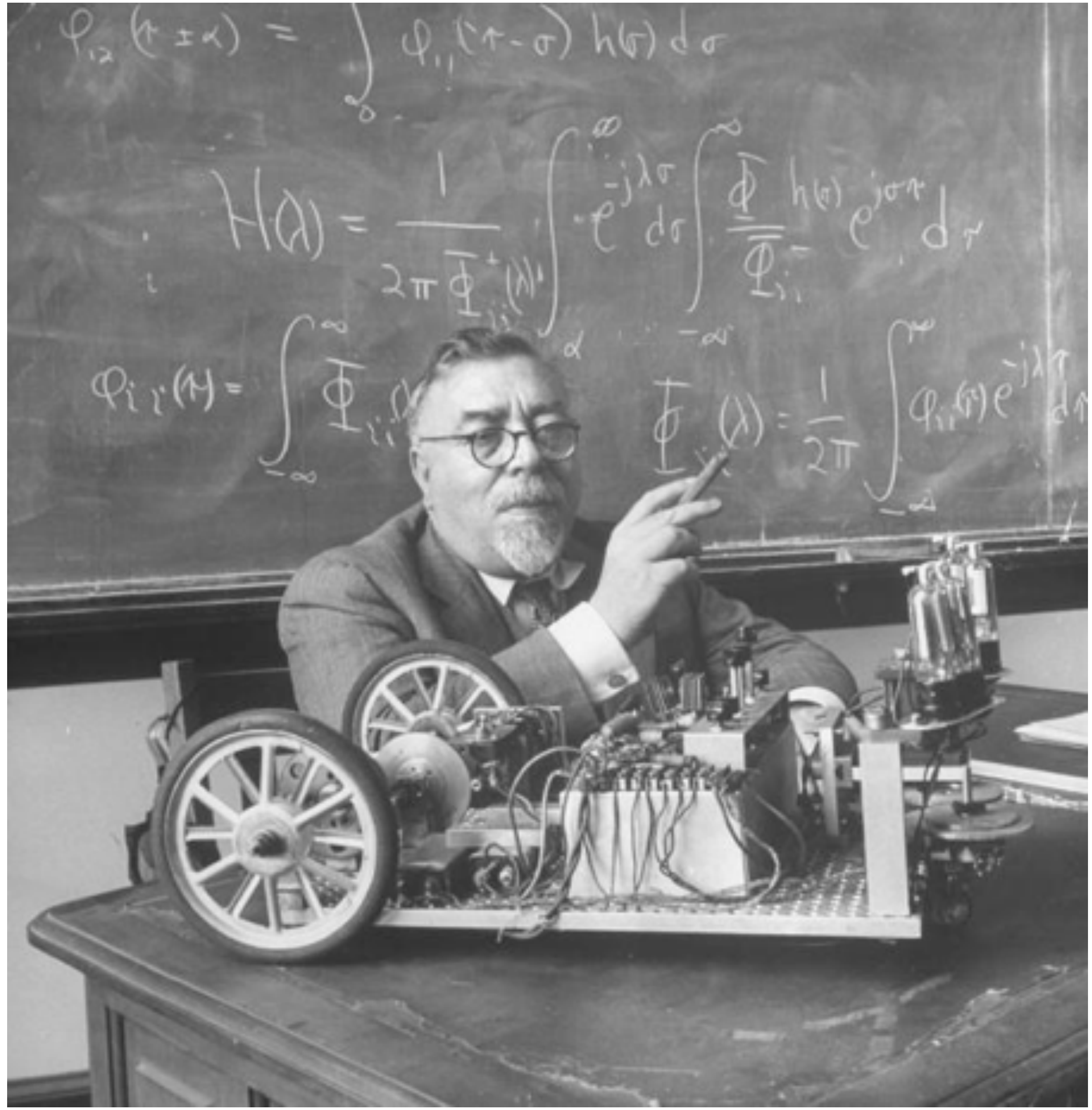
$$D = \frac{32}{243}\frac{mc^2}{\pi\mu R}$$

Ann. Phys. **21**, 756 (1906)

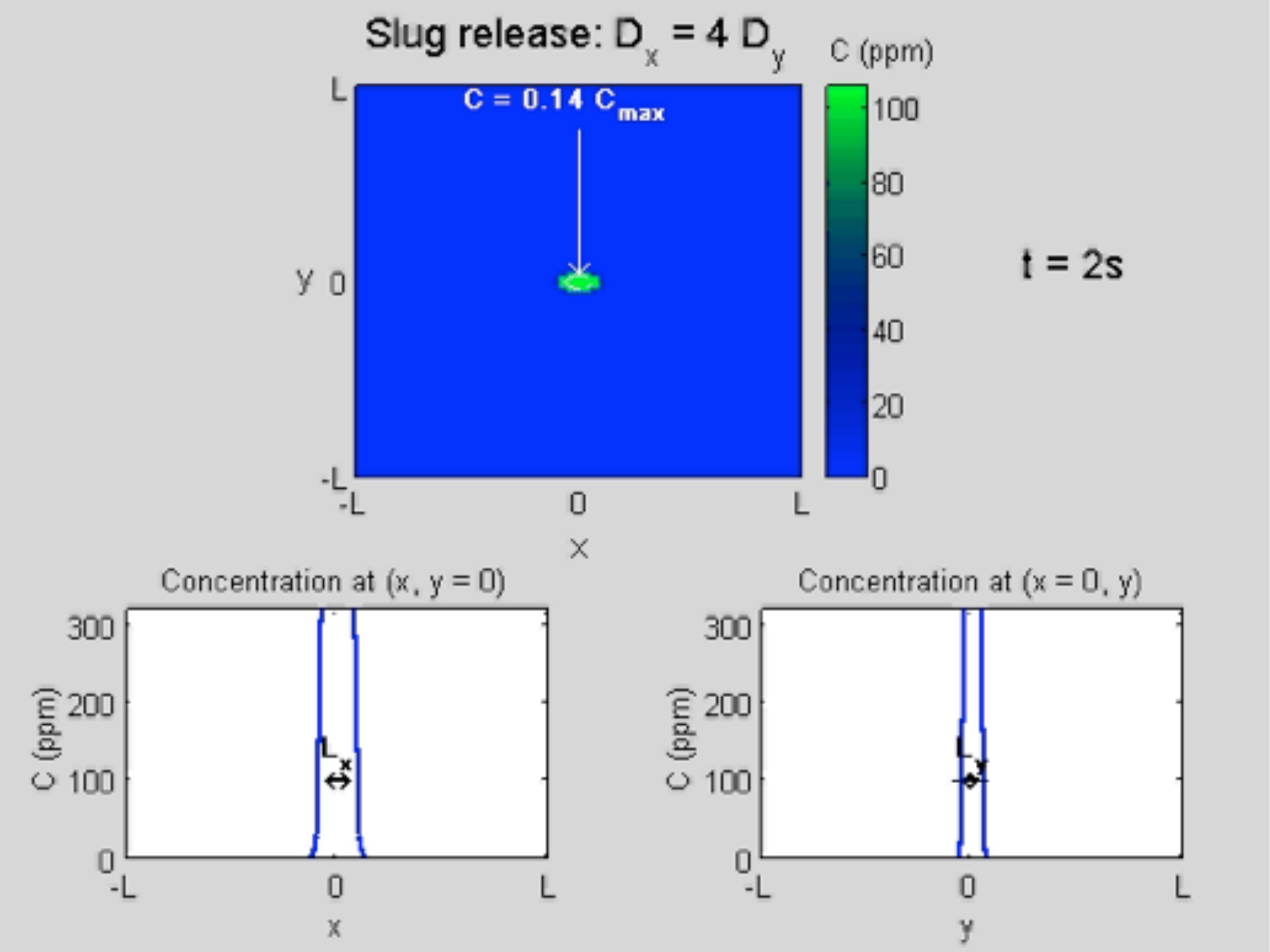
Norbert Wiener

(1894-1864)

MIT



Diffusion of an Instantaneous Point Source



This animation depicts the diffusion of a discrete mass released at (x = 0, y = 0, t = 0). The diffusion is anisotropic, Dx = 4 Dy. The length scales grow in proportion to the square root of the diffusion, such that the dimensions of the cloud are anisotropic, with Lx = 2 Ly. Note that the profiles of concentration along the x- and y-axes are Gaussian in shape.