https://quantum-mechanics.gatech.edu/

Pre-requisites

1) Complex numbers $i^2 = -1$

$z = 2 + 3i$ $\quad z^* = 2 - 3i$

$|z|^2 = z \cdot z^* = (2+3i)(2-3i) = 2^2 - 3^2 i^2 = 2^2 + 3^2 = 13$

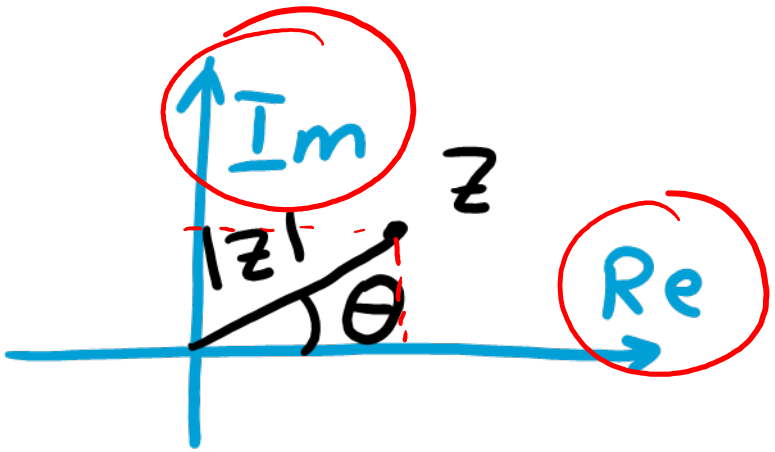
Euler's formular:

$$e^{i\theta} = \cos\theta + i\sin\theta$$

$$e^{-i\theta} = \cos\theta - i\sin\theta$$

$$\cos\theta = \frac{e^{i\theta} + e^{-i\theta}}{2}$$

$$\sin\theta = \frac{e^{i\theta} - e^{-i\theta}}{2i}$$



$$z = |z| \cdot e^{i\theta}$$

2) Linear Algebra

$$A = \begin{pmatrix} 1 & 2i \\ -2i & 2 \end{pmatrix} \qquad B = \begin{pmatrix} 3 & 4i \\ 5i & 4 \end{pmatrix}$$

$A+B$, $A \cdot B$, $\det \|A\|$

Eigenvalues

Eigenvectors

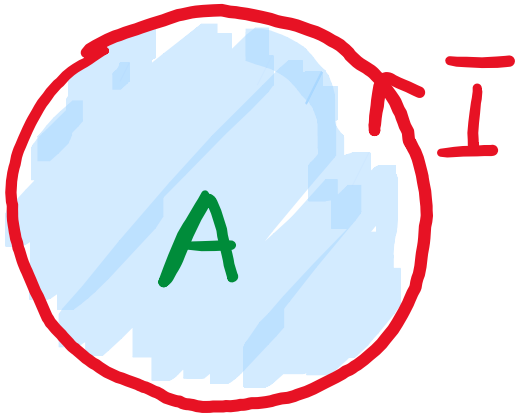
3) Calculus

In particular: Taylor Series

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!}$$

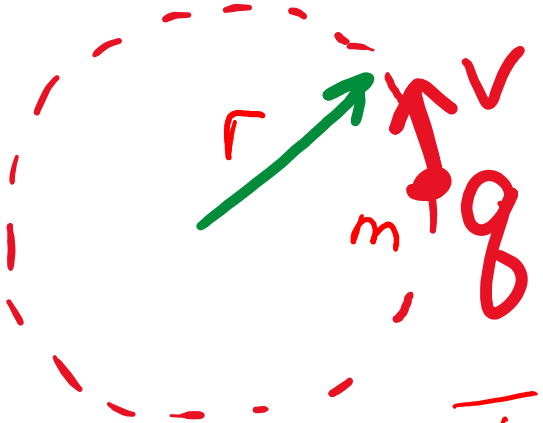
4) Differential Equations

Magnetic dipole moment



$$\mu = I A \quad \text{(in SI)}$$

$$\mu = \frac{I A}{c} \quad \text{(in Gaussian units)}$$



$$I = \frac{q}{T}$$

$$T = \frac{2\pi r}{v}$$

$$I = \frac{q \cdot v}{2\pi r}$$

$$\mu = \frac{q v}{2\pi r} \cdot \frac{\pi r^2}{c} = \frac{q \cdot m v r}{2 c\, m} = \frac{q}{2mc} \cdot L$$

(I over $\frac{qv}{2\pi r}$, A over $\frac{\pi r^2}{c}$, $L = p \cdot r$ over L)

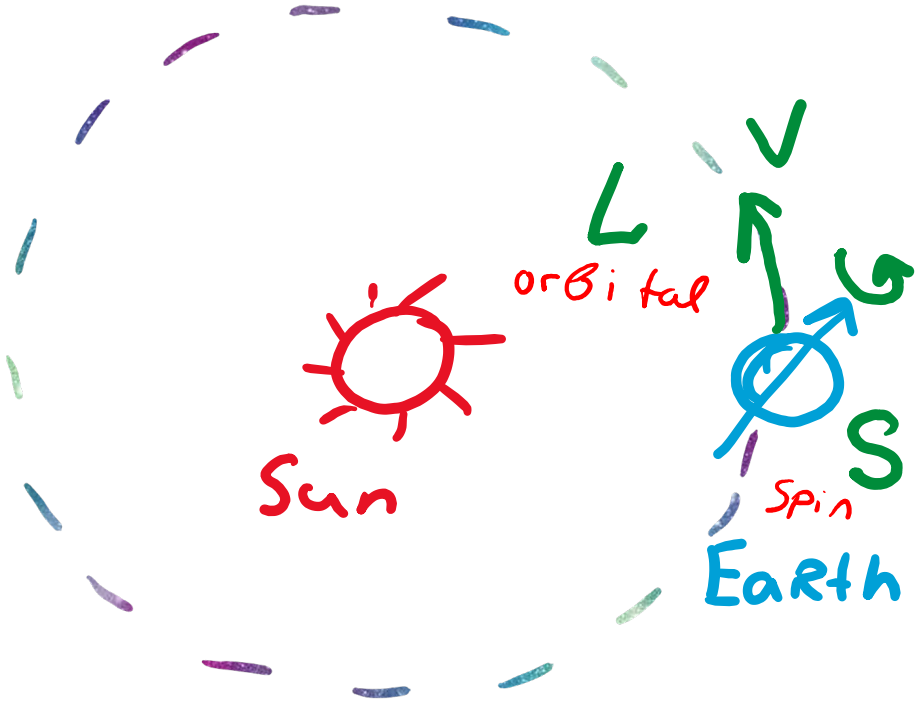
$$\vec{\mu} = \frac{q}{2mc}\vec{L}$$

$$\vec{\mu} = \frac{qg}{2mc}\vec{S}$$

$g = 2.00$ for electron

5.58 for proton

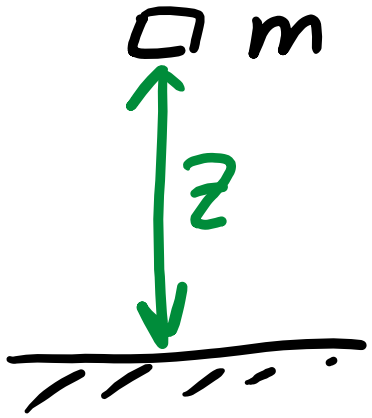
. . . .



Potential energy and force:

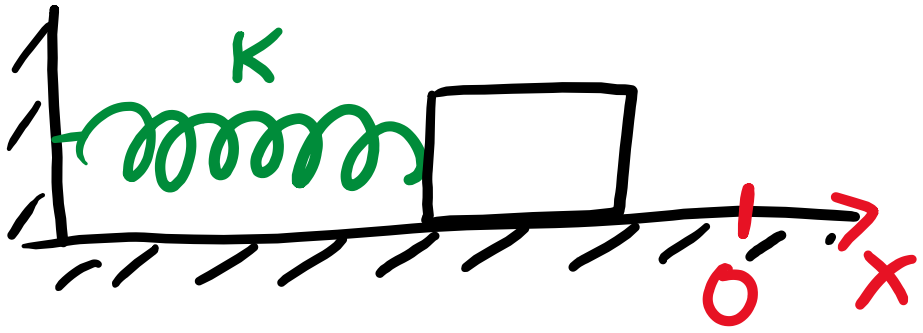
$$F = -\nabla U$$

Examples:



$$U = mgz$$

$$F = -\frac{\partial}{\partial z}(mgz) = -mg$$



$$U = \frac{1}{2}kx^2$$

$$F = -\frac{\partial}{\partial x}\left(\frac{1}{2}kx^2\right) = -kx$$

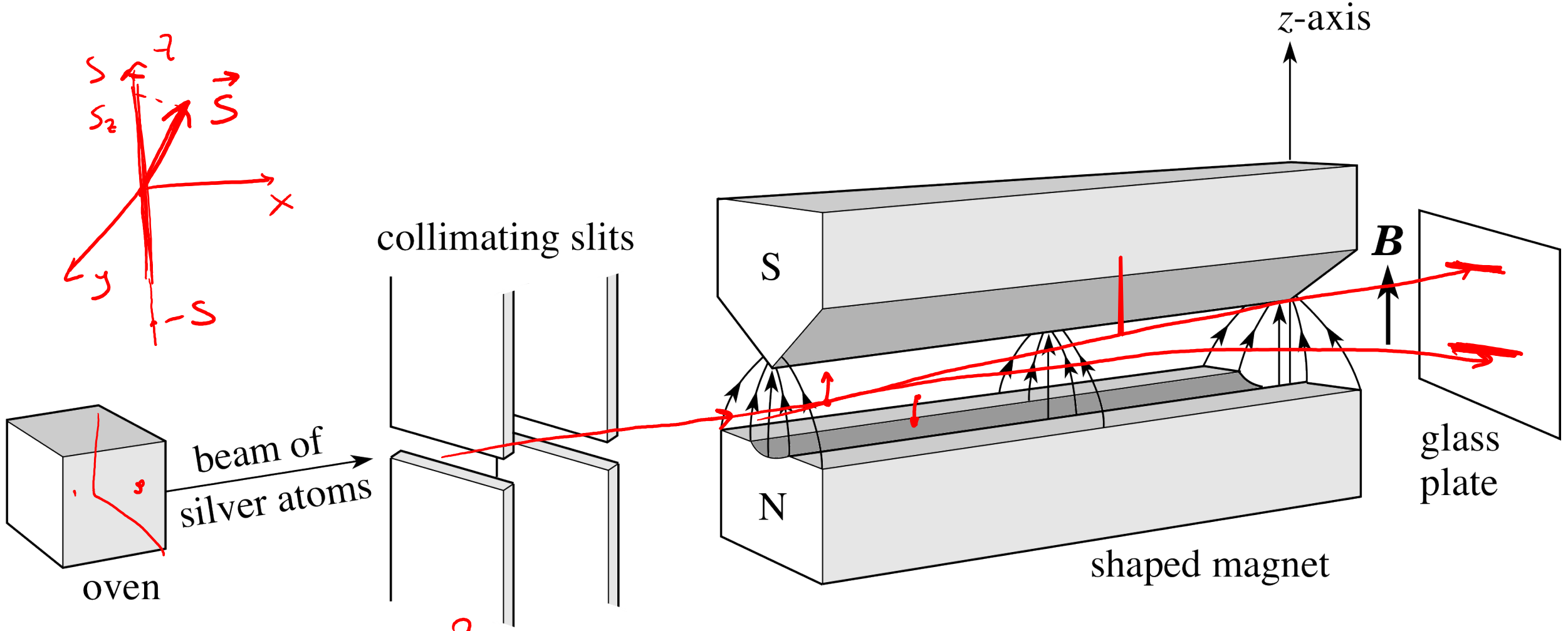
Magnetic dipole in inhomogeneous magnetic field

Energy of interaction: $U = -\vec{\mu} \cdot \vec{B}$

Force: $F = -\nabla U = \nabla(\vec{\mu} \cdot \vec{B})$

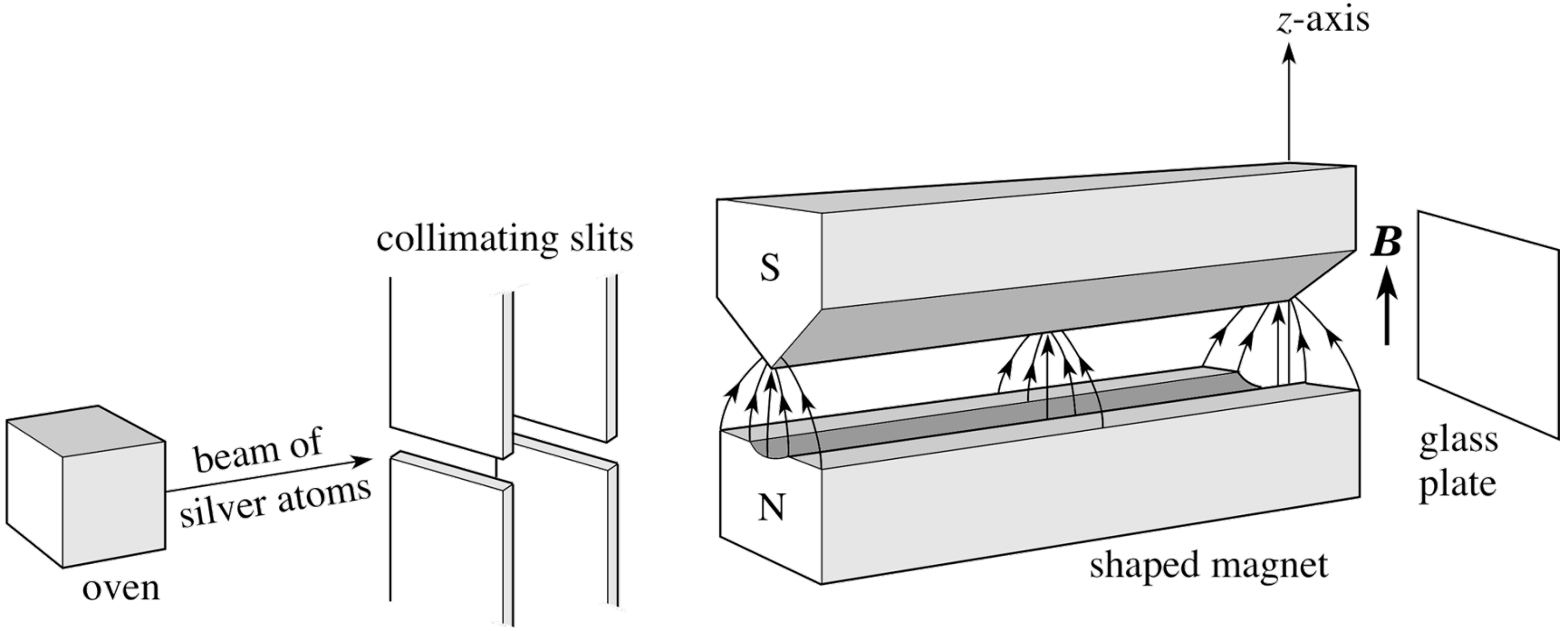
Assume $\frac{\partial B_z}{\partial z}$ is Large

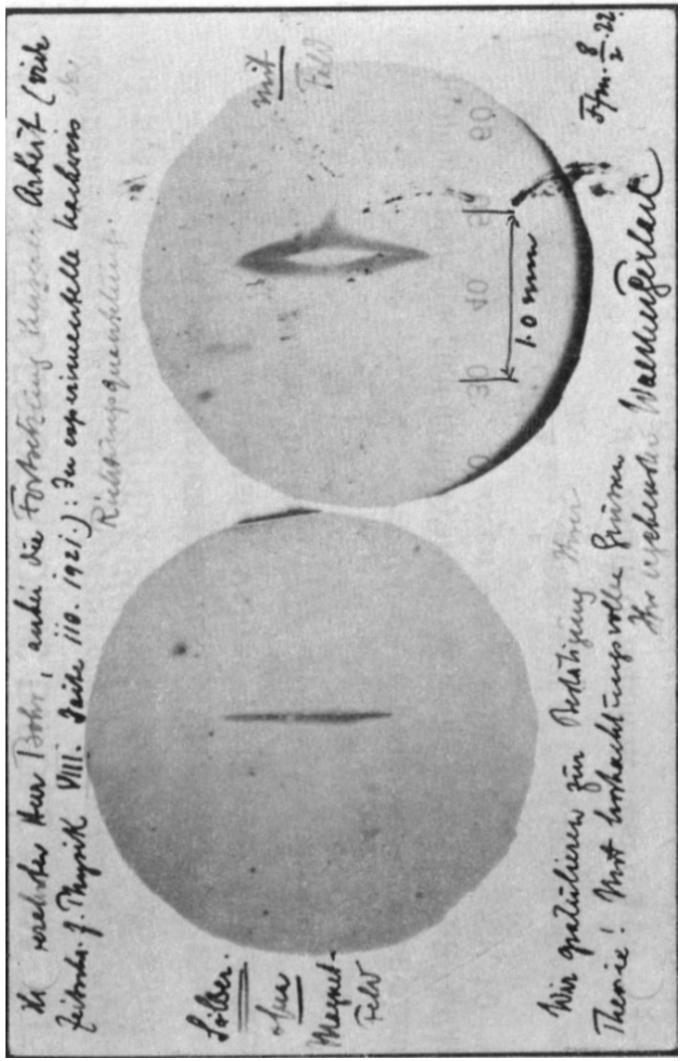
$$F_z = \mu_z \cdot \frac{\partial B_z}{\partial z}$$



$$F_z = \mu_z \frac{\partial B_z}{\partial z}$$

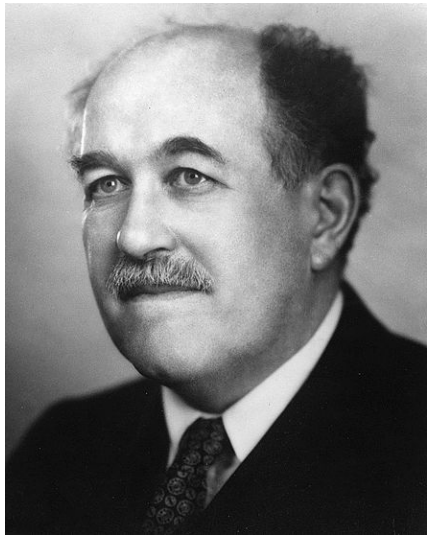
$$\mu_z = \frac{g q}{2mc} S_z$$





$$S_z = \pm \frac{\hbar}{2}$$

$$\hbar = \frac{h}{2\pi} = 1.055 \cdot 10^{-34}\ \mathrm{J \cdot s}$$



Otto Stern 1888 –1969

1943 Nobel Prize in Physics, "for his contribution to the development of the molecular ray method and his discovery of the magnetic moment of the proton“. Became a US citizen in 1939 and, during World War II, served as a consultant to the War Department. In 1945, he retired and settled in Berkeley, California. He often traveled to Europe, but “never revisited Germany and refused to collect the pension due him, expressing in this way his abomination for Nazism

Walther Gerlach 1889 –1979

During the Third Reich steadfastly resisted fanatics who attacked Einstein and “Jewish science”; never joined the Nazi party. Yet in 1944, he became head of the German nuclear research program. At the end of the war, Gerlach was among the ten leading German scientists detained at Farm Hall by Allied forces. Later, he contributed much to the rebuilding of German science and campaignedto ban nuclear weapons.

Minesweeper – one of several projects developed under the supervision of Gerlach