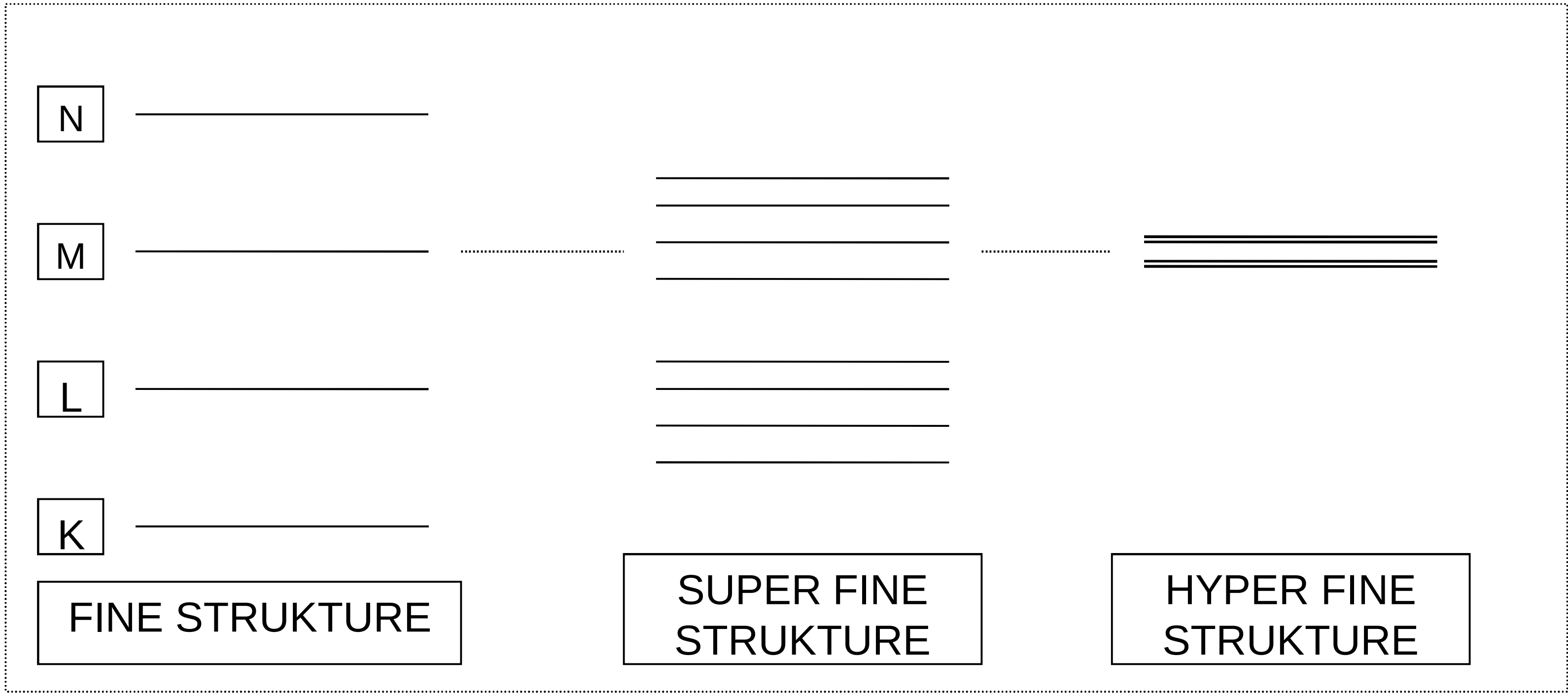
ELEKTRON SPIN

BUKTI EKSPERIMENT TENTANG ADANYA SPIN

FINE STRUKTURE



KULIT	K	K	L	M	N
n	:	1	2	3	4
l	:	0	0,1	...	(n-1)
s	:	$\frac{1}{2}, -\frac{1}{2}$			$\vec{S}$

$$\vec{J} = \vec{L} + \vec{S}$$

$$\left|\vec{J} + |l+s| \ldots |l+s-1|\right|$$

$$\ldots |l-s|$$

Contoh : Kulit M → n = 3, l = 0,1,2

$$l = 0 \Rightarrow \left|\vec{J}\right| = \frac{1}{2} \Rightarrow m_s = -\frac{1}{2}, +\frac{1}{2}$$

$$l = 1 \Rightarrow \left|\vec{J}\right| = \frac{3}{2} \Rightarrow m_s = -\frac{3}{2}, -\frac{1}{2} + \frac{1}{2}, \frac{3}{2}$$

$$l = 2 \Rightarrow \left|\vec{J}\right| \begin{cases} = \dfrac{1}{2} \Rightarrow m_s = -\dfrac{1}{2}, \dfrac{1}{2} \\ = \dfrac{5}{2} \Rightarrow m_s = -\dfrac{5}{2}, -\dfrac{3}{2}, -\dfrac{1}{2} + \dfrac{1}{2}, \dfrac{3}{2}, \dfrac{5}{2} \\ = \dfrac{3}{2} \Rightarrow m_s = -\dfrac{3}{2}, -\dfrac{1}{2} + \dfrac{1}{2}, \dfrac{3}{2} \end{cases}$$

$$l = 0 \ (s) \qquad j = \frac{1}{2} \Rightarrow m_s = 2e$$

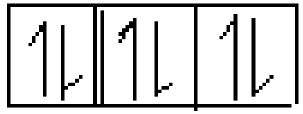
$$l = 1 \ (p) \qquad j = \frac{1}{2} \Rightarrow m_s = 2e$$

$$l = 1 \ (p) \qquad j = \frac{3}{2} \Rightarrow m_s = 4e$$

$$l = 2 \ (d) \qquad j = \frac{3}{2} \Rightarrow m_s = 4e$$

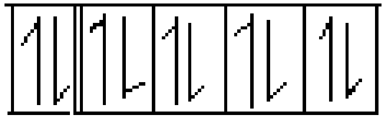
$$l = 2 \ (d) \qquad j = \frac{5}{2} \Rightarrow m_s = 6e$$

$J = \frac{1}{2}$ l = 0 3



l = 1

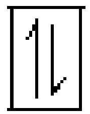
$J = \frac{3}{2}$ $J = \frac{5}{2}$



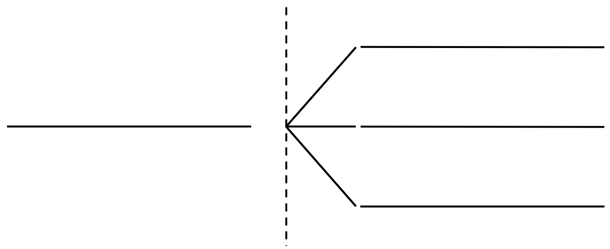
l = 2

S = bulat $\Rightarrow$ *partikel boson*

$S = \frac{1}{2}$, *bilangan ganjil* $\Rightarrow$ *fermion* $J = \frac{1}{2}$ l = 0



ANOMALI EFEK ZEEMAN



B = 0

$B \neq 0$

Untuk Z = genap $\Rightarrow$ benar atom akan pecah masuk ke medan B sejumlah bil. Ganjil memperkuat asumsi bahwa l = bulat (efek zeeman normal).

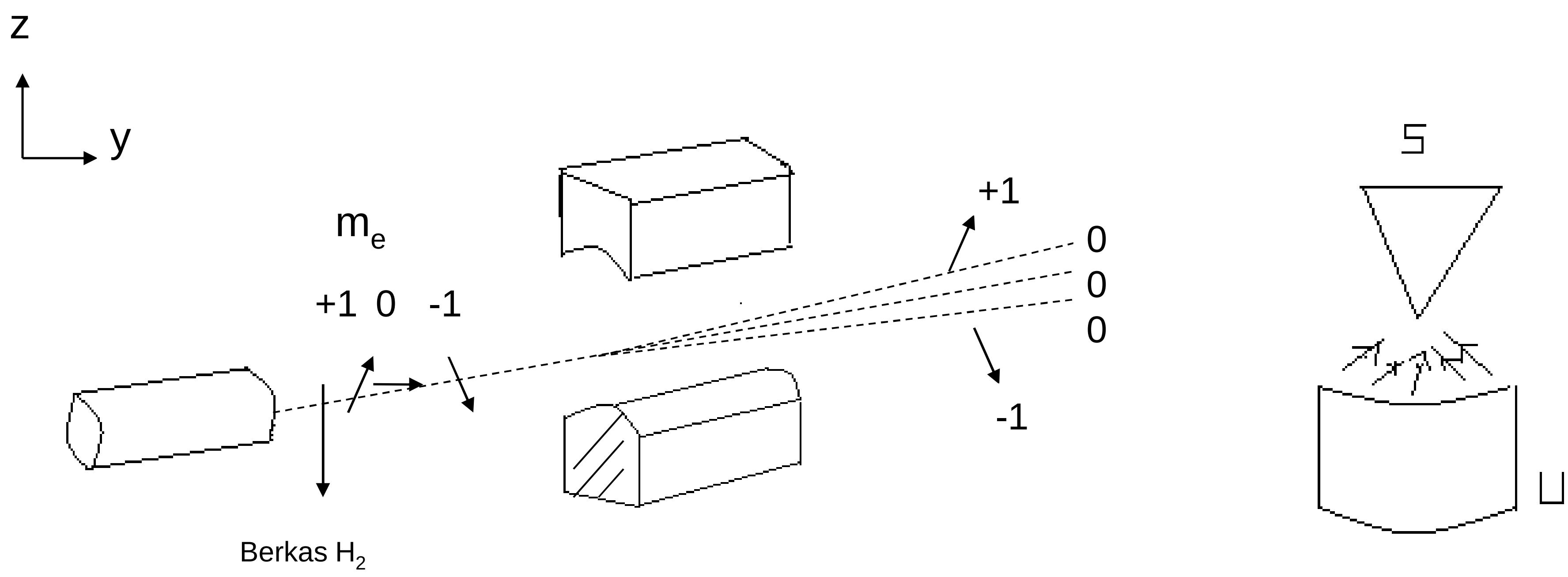
Ganjil $\Rightarrow$ atom pecah bil. Genap $\Rightarrow$ l = bulat.

Tak normal $\Rightarrow$ anomali

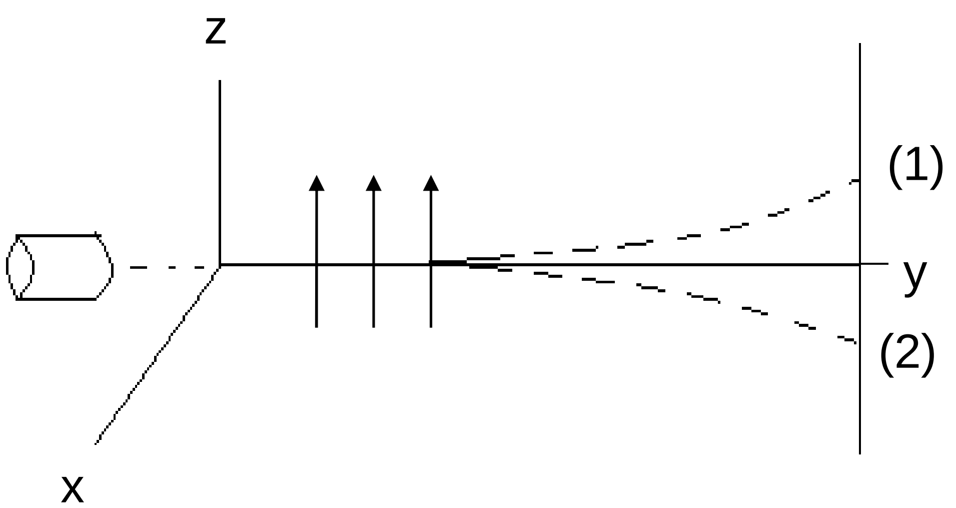
Dipengaruhi

$$\vec{B} = efek\ zeeman$$

$$E = efek\ Strake$$



Seberkas atom dilewatkan dalam daerah yang terdapat $\vec{B}\ (B_z\ \hat{z})$. Atom-atom dengan arah momen dipole berlawanan mengalami gaya dalam dua arah yang berlawanan.



$$\vec{M} = \frac{\mu B}{\hbar}\vec{L} \quad \text{dimana}$$

$$\mu = Magneton\,Bohr = \frac{q\hbar}{2m_e}$$

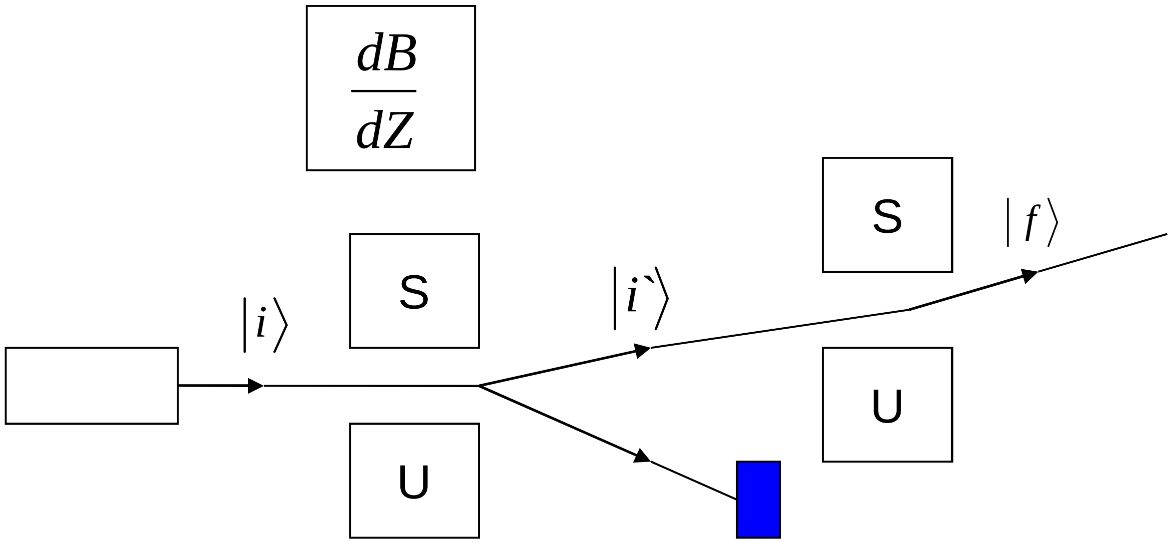
$$\vec{M} = momen\,dipole\,magnet$$

$$\vec{L} = momentum\,sudut\,orbital$$

ANALISIS PERCOBAAN STERN GERLACH

$$|1\rangle = |S_z = +\rangle \;;\; |2\rangle = |S_z = -\rangle \qquad \langle + | i \rangle = a\langle + | + \rangle + b\langle + | - \rangle = 1$$

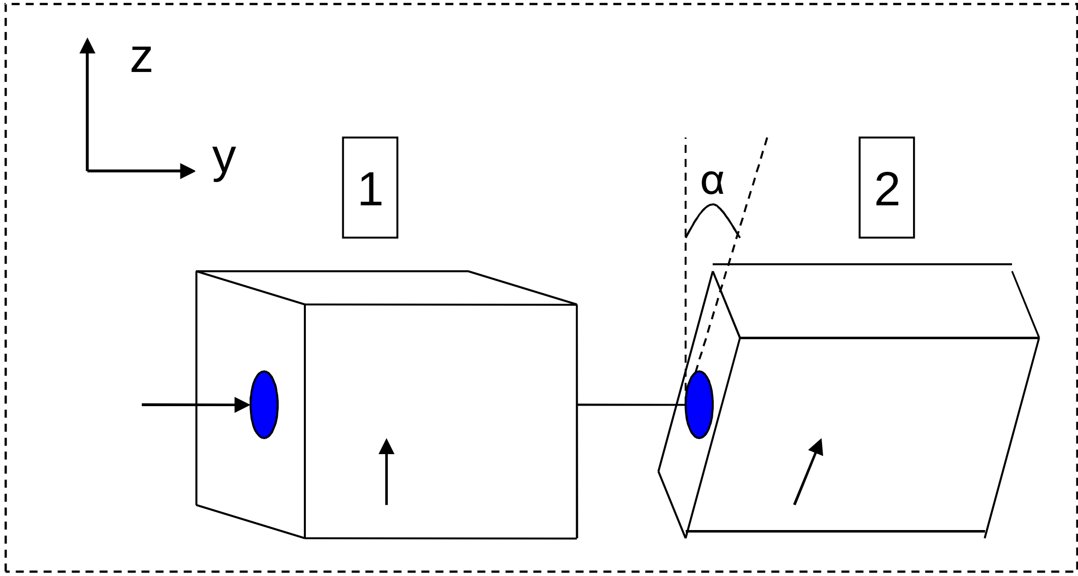
$$|i\rangle = a|S_z = +\rangle + b|S_z = -\rangle \qquad \langle - | i \rangle = a\langle - | + \rangle + b\langle - | - \rangle = 1$$



$$|\langle + | i \rangle|^2 = |\langle - | i \rangle|^2 \quad \Leftrightarrow \quad \langle + | i \rangle\langle + | i \rangle^{\times} + \langle - | i \rangle\langle - | i \rangle^{\times}$$

Bagaimana jika divais SG yang kedua membentuk sudut α dengan yang pertama?

FILTER STERN GERLACH



$$untuk\_\alpha = 90$$

$$z \Leftrightarrow x$$

$$\left|S_x = \pm\right\rangle \neq \left|S_z = \pm\right\rangle$$

$$filter(1)\left|S_z = +\right\rangle,\ filter(2) = \left|S_x = -\right\rangle$$

$$\left\langle S_x = + \middle| S_z = +\right\rangle = \neq 0\, dan$$

$$\left\langle S_x = - \middle| S_z = +\right\rangle = \neq 0$$

$$\left\langle S_z = + \middle| S_x = -\right\rangle \left\langle S_x = - \middle| S_z = +\right\rangle + \left\langle S_z = - \middle| S_x = -\right\rangle \left\langle S_x = - \middle| S_z = +\right\rangle$$

OPERATOR DAN MATRIKS

Berkas electron mula-mula $|i\rangle$ melewati divais SG menjadi $|f\rangle$. Amplitude proses $\langle f|A|i\rangle$;
A = operator sebagai representasi proses dalam divais SG

$$\langle f|A|i\rangle = \sum_{\alpha,\beta} \langle f|\alpha\rangle\langle\alpha|A|\beta\rangle\langle\beta|i\rangle$$

$\langle\alpha|A|\beta\rangle$ *dengan element matriks A*

	$\lvert S_z = +\rangle$	$\lvert S_z = -\rangle$
$\lvert S_z = +\rangle$	$\langle S_z = +\lvert A \rvert S_z = +\rangle$	$\langle S_z = +\lvert A \rvert S_z = -\rangle$
$\lvert S_z = -\rangle$	$\langle S_z = -\lvert A \rvert S_z = +\rangle$	$\langle S_z = -\lvert A \rvert S_z = -\rangle$

$$\begin{bmatrix} \frac{\hbar}{2} & 0 \\ 0 & \frac{\hbar}{2} \end{bmatrix}$$

Matriks S_y dan S_x dan solusi persamaan eigen

$$|S_x = \pm\rangle = \frac{1}{\sqrt{2}}\{|S_z = +\rangle \pm |S_z = -\rangle\}$$

[S_x,S_y] = $\hbar S_z$ $\qquad$ $x, y, z\ silidik$

$$|S_y = \pm\rangle = \frac{1}{\sqrt{2}} - \{|S_z = +\rangle \pm i|S_z = -\rangle\}$$

Ruang keadaan spin $\left|s,m\right\rangle$ *dengan*

$$S^2\left|s,m\right\rangle = s(s+1)\hbar^2\left|s,m\right\rangle$$
$$S_z\left|s,m\right\rangle = m\hbar\left|s,m\right\rangle$$

$$S_+ = S_x + iS_y \quad ; \quad S_- = S_x - iS_y \quad ; \quad \Rightarrow \quad S_x = \frac{1}{2}\left(S_+ + S_-\right) \quad ; \quad S_y = \frac{1}{2i}\left(S_+ + S_-\right)$$

$$S_x\left|i\right\rangle = \upsilon\left|i\right\rangle \quad \Rightarrow \quad \frac{\hbar}{2}\begin{pmatrix}0 & 1\\ 1 & 0\end{pmatrix}\begin{pmatrix}a\\ b\end{pmatrix} = \lambda\begin{pmatrix}a\\ b\end{pmatrix}$$

$$\begin{bmatrix}-\dfrac{2\lambda}{\hbar} & 0\\ 0 & -\dfrac{2\lambda}{\hbar}\end{bmatrix} = 0 \Rightarrow \upsilon = \pm\frac{\hbar}{2} \quad \rightarrow a = b = \frac{1}{\sqrt{2}} \qquad a = -b = -\frac{1}{\sqrt{2}}$$

$$+\frac{1}{2}\frac{\hbar}{2} \quad dan \quad -\frac{1}{2}\hbar \quad \rightarrow \quad nilai\ \ eigen$$

$$\begin{pmatrix}\dfrac{1}{\sqrt{2}}\\ \dfrac{1}{\sqrt{2}}\end{pmatrix} \ dan \ \begin{pmatrix}-\dfrac{1}{\sqrt{2}}\\ \dfrac{1}{\sqrt{2}}\end{pmatrix} \rightarrow \ spinor\ \ eigen$$

MATRIKS PAULI

$$S_X = \frac{1}{2}\hbar\sigma_X \quad : \quad S_Y = \frac{1}{2}\hbar\sigma_Y \qquad S_Z = \frac{1}{2}\hbar\sigma_Z \qquad dengan$$

$$\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \quad ; \quad \sigma_y = \begin{pmatrix} 0 & -i \\ 1 & 0 \end{pmatrix} \qquad ; \qquad \sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

$$\sigma_i^2 = I \quad ; \quad \sigma_i\sigma_j + \sigma_j\sigma_i = 2\sigma_{ij} I \quad ; \quad \left[\sigma_x, \sigma_y\right] = 2i\sigma_z$$

$$\vec{S} = \hbar\frac{\vec{\sigma}}{2} \;\rightarrow\; \sigma^2 = 3 \;\rightarrow\; S^2 = \frac{\hbar^2\sigma^2}{4} = s(s+1)\hbar^2 = \frac{3}{4}\hbar^2$$

TRANSFORMASI MATRIKS

Satu filter SG disusun dalam keadaan $|S_z = \alpha\rangle$ yang lain diukur sehingga $\left|\langle S_y = i | S_z = \alpha\rangle\right|^2$ mendapatkan berkas keadaan S_y. semua data exp. yang mungkin diberikan oleh element-element yang dinamakan matrik transformasi.