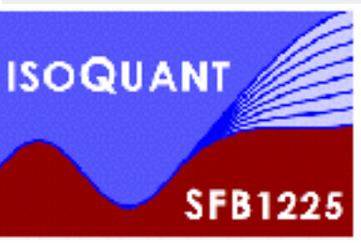
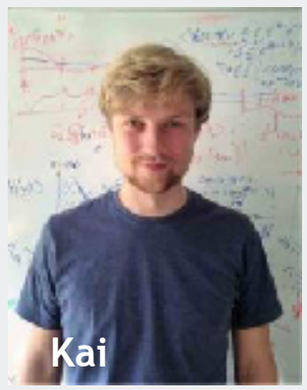




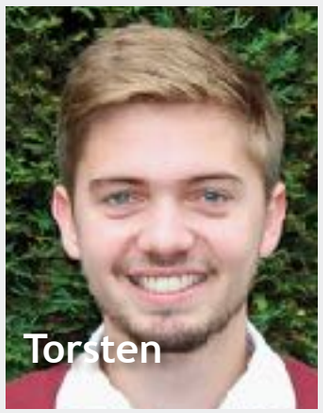
Synthetic Quantum Systems

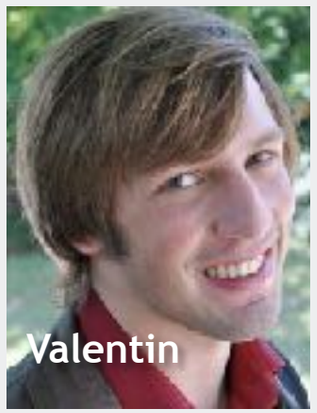
SynQS

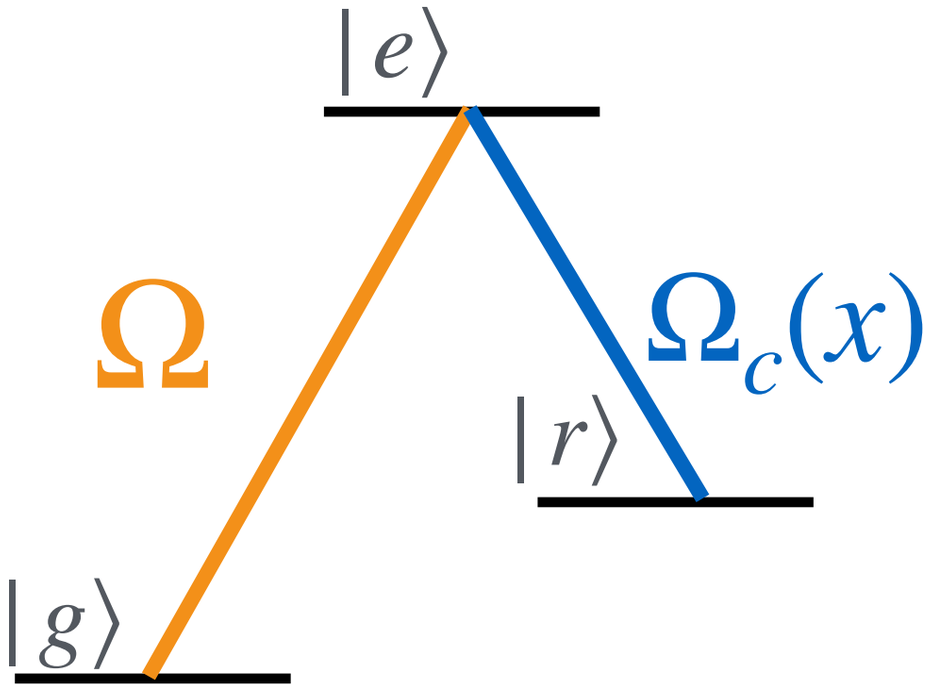


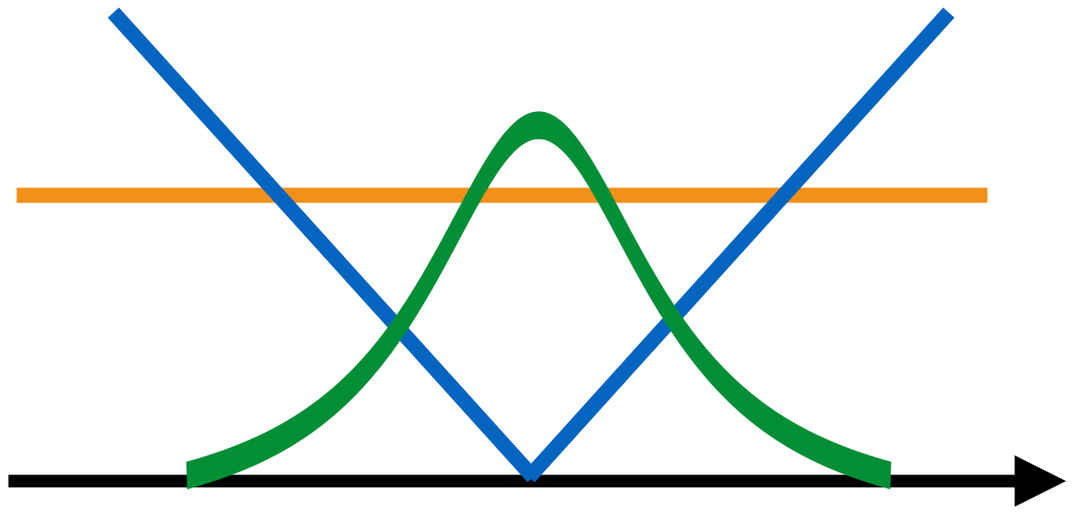
On the road to dynamical gauge fields in cold atoms

Fred Jendrzejewski









geometric scalar potential

Goldman et al. RPP **77** 126401 (2014)
Jendrzejewski et al. PRA **94** 063422 (2016)
Lacki et al. PRL **117** 233001 (2016)

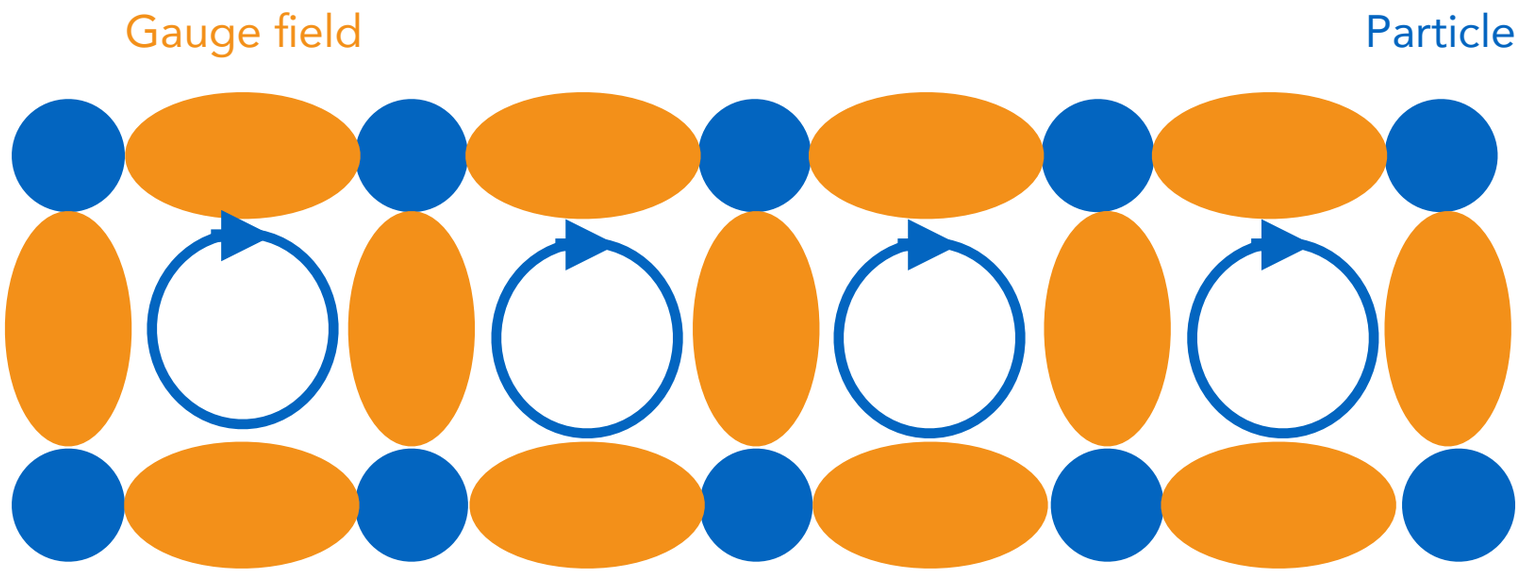
PHYSICAL REVIEW LETTERS **120,** 083601 (2018)

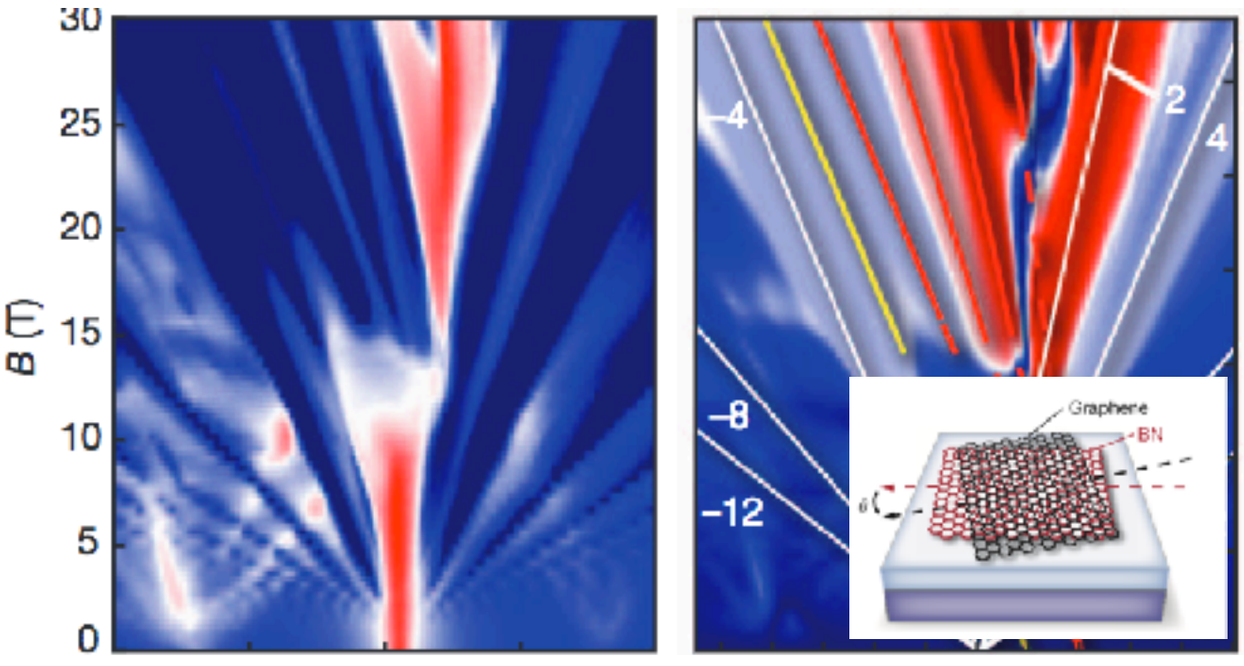
Editors' Suggestion | Featured in Physics

Dark State Optical Lattice with a Subwavelength Spatial Structure

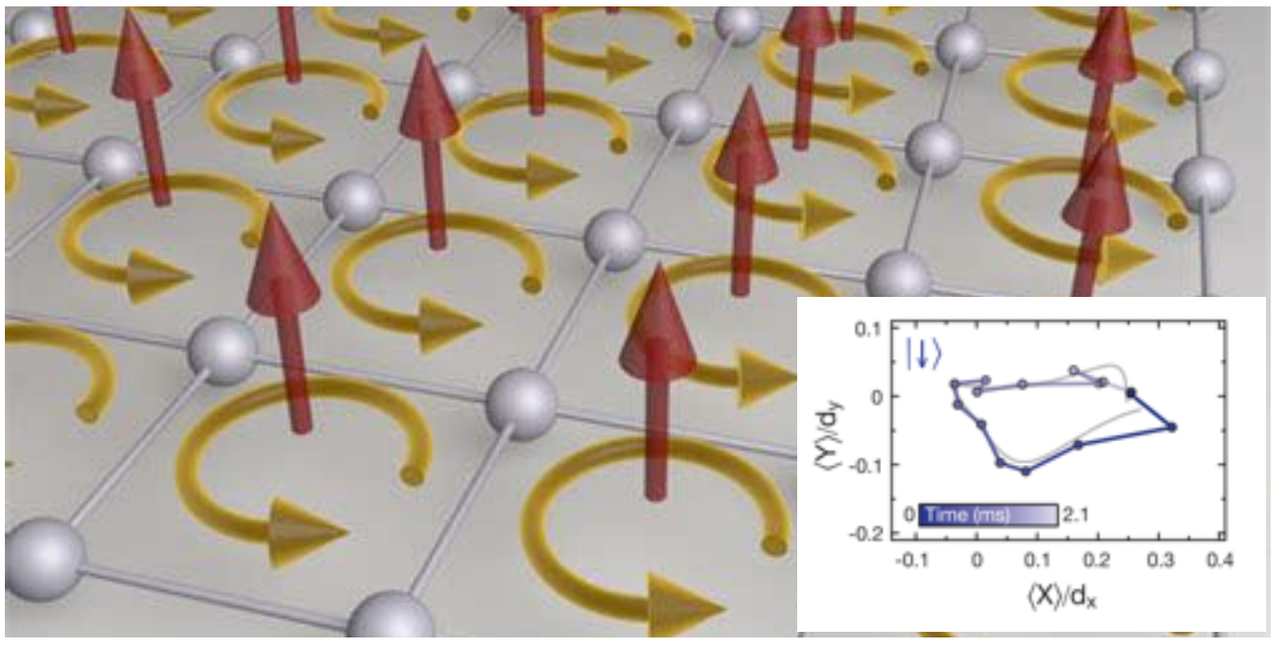
Y. Wang (王扬),[1,*] S. Subhankar,[1] P. Bienias,[1] M. Łącki,[2,3,4] T-C. Tsui (崔子俊),[1]
M. A. Baranov,[3,4] A. V. Gorshkov,[1,5] P. Zoller,[3,4] J. V. Porto,[1] and S. L. Rolston[1]

$$\hat{H} = -t \sum_i \left(\hat{a}^\dagger_{j+1} e^{iaeA_j} \hat{a}_j + \hat{a}^\dagger_j e^{-iaeA_j} \hat{a}_{j+1} \right)$$





Dean et al.Nature 497, 598 (2013)



M. Aidelsburger et al. PRL 111, 185301 (2013)

Simulation of Higgs decay from CMS

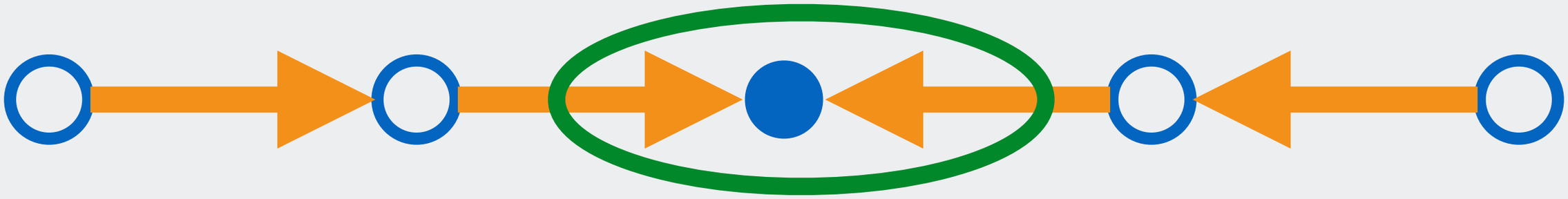
$$\mathscr{L}_{QED} = \bar{\psi}\left(i\gamma^{\mu}D_{\mu} - m\right)\psi - \frac{1}{4}F^{\mu\nu}F_{\mu\nu}$$

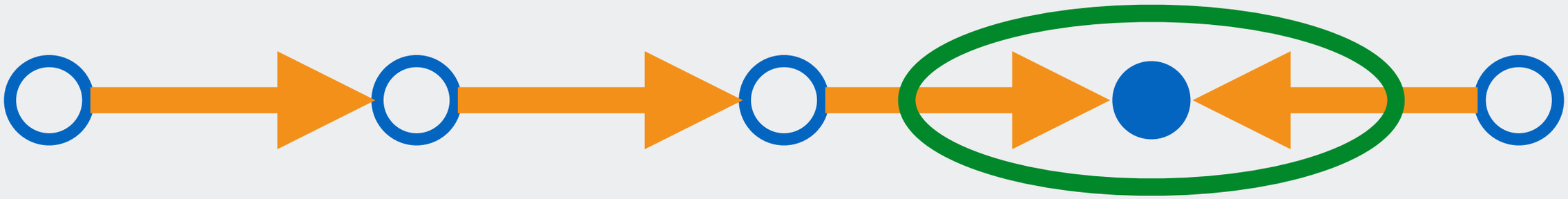
$$\mathscr{L}_{QCD} = \sum_{fi}\bar{\psi}^{fi}\left(i\gamma^{\mu}D_{\mu ij} - m_f\right)\psi^{fi} - \frac{1}{2g^2}Tr\left(G^{\mu\nu}G_{\mu\nu}\right)$$

Conserved
local charges

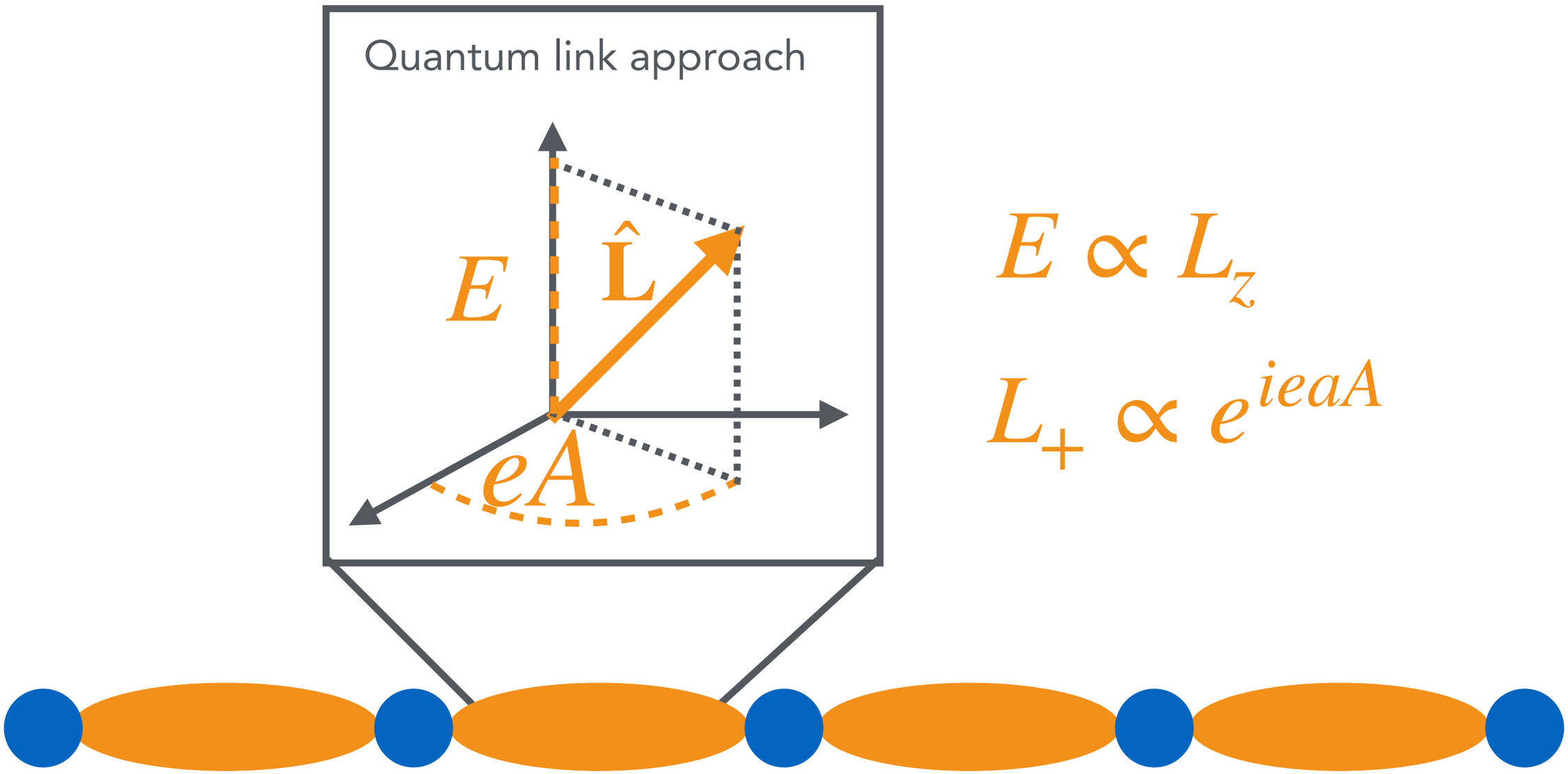
=

Conserved
local gauge symmetry





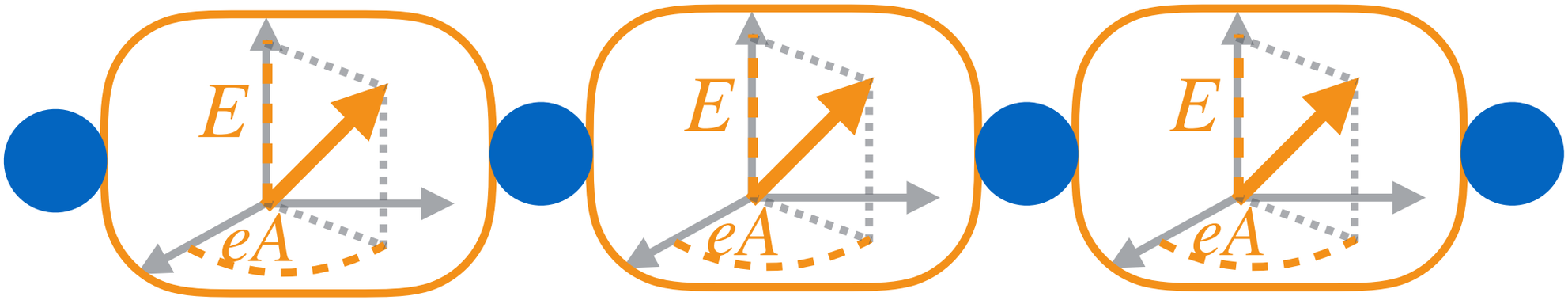
$$\operatorname{div}\,\mathbf{E}(\mathbf{r}) = e\rho(\mathbf{r})$$

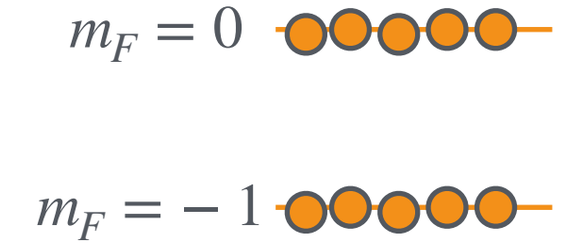


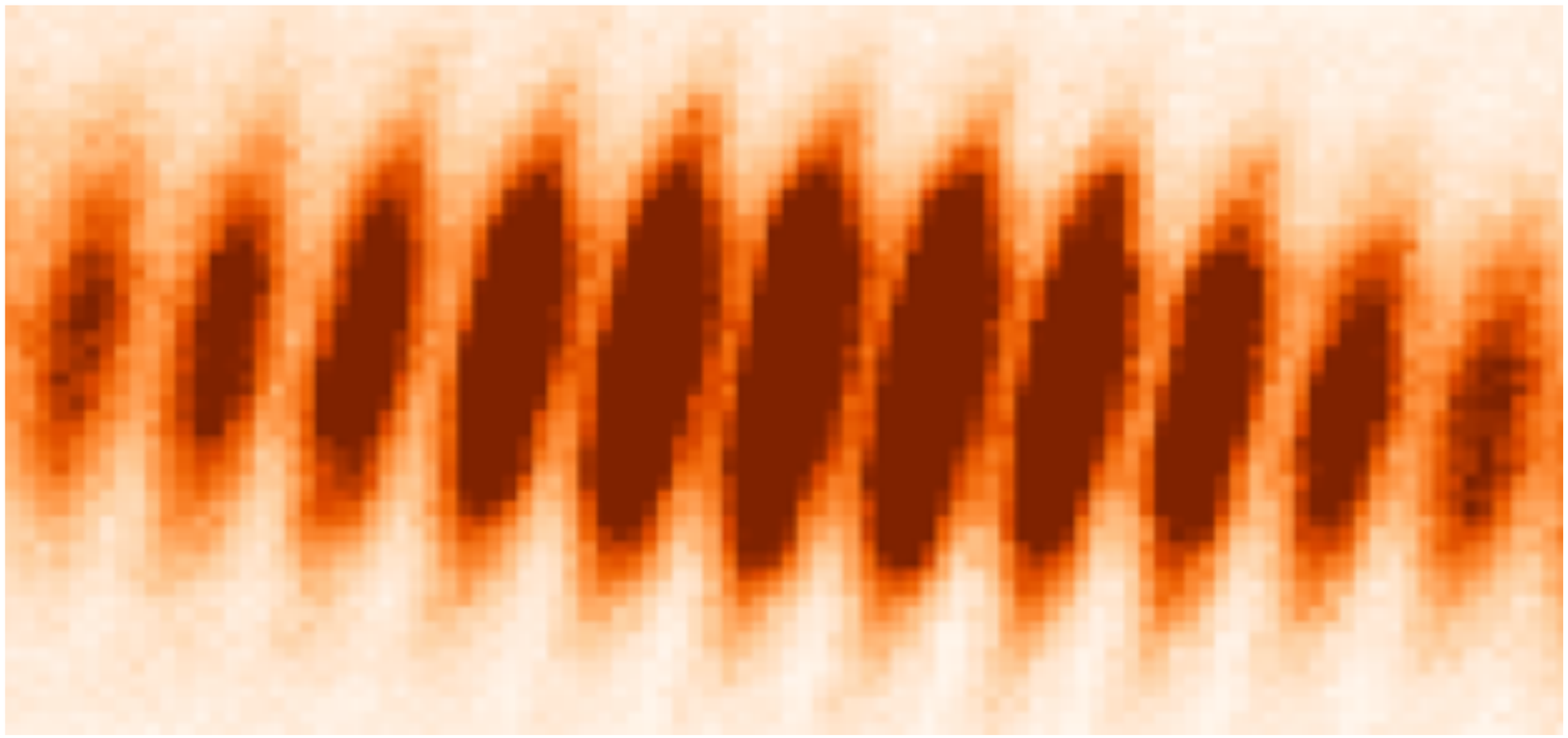
$$E \propto L_z$$

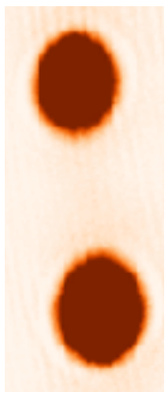
$$L_+ \propto e^{ieaA}$$

Wiese, Ann. Phys. **525** 777 (2013)
S. Chandrasekharan and U.-J. Wiese, Nucl. Phys. B **492**, 455 (1997).





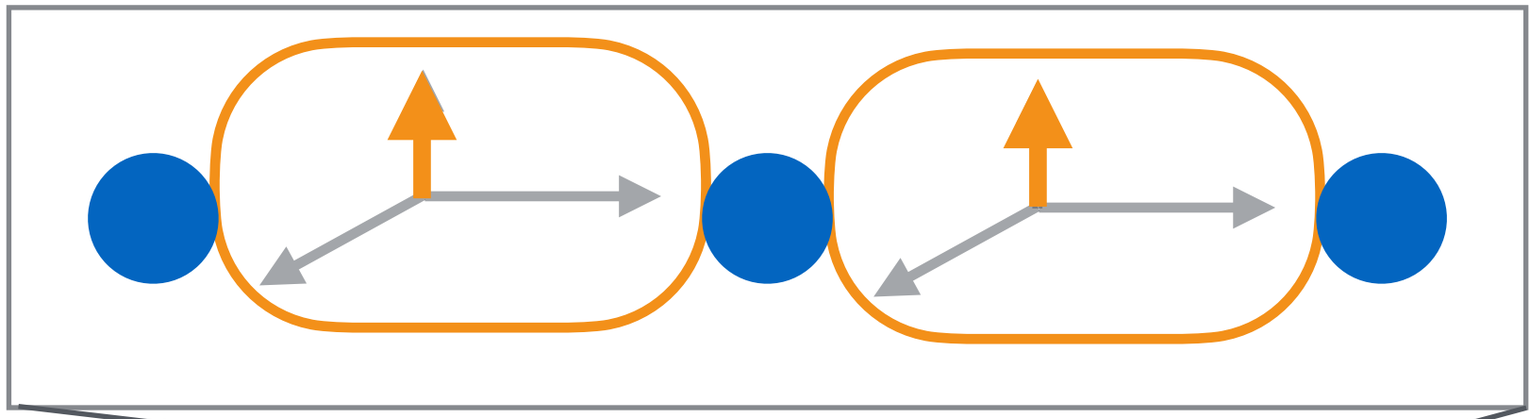


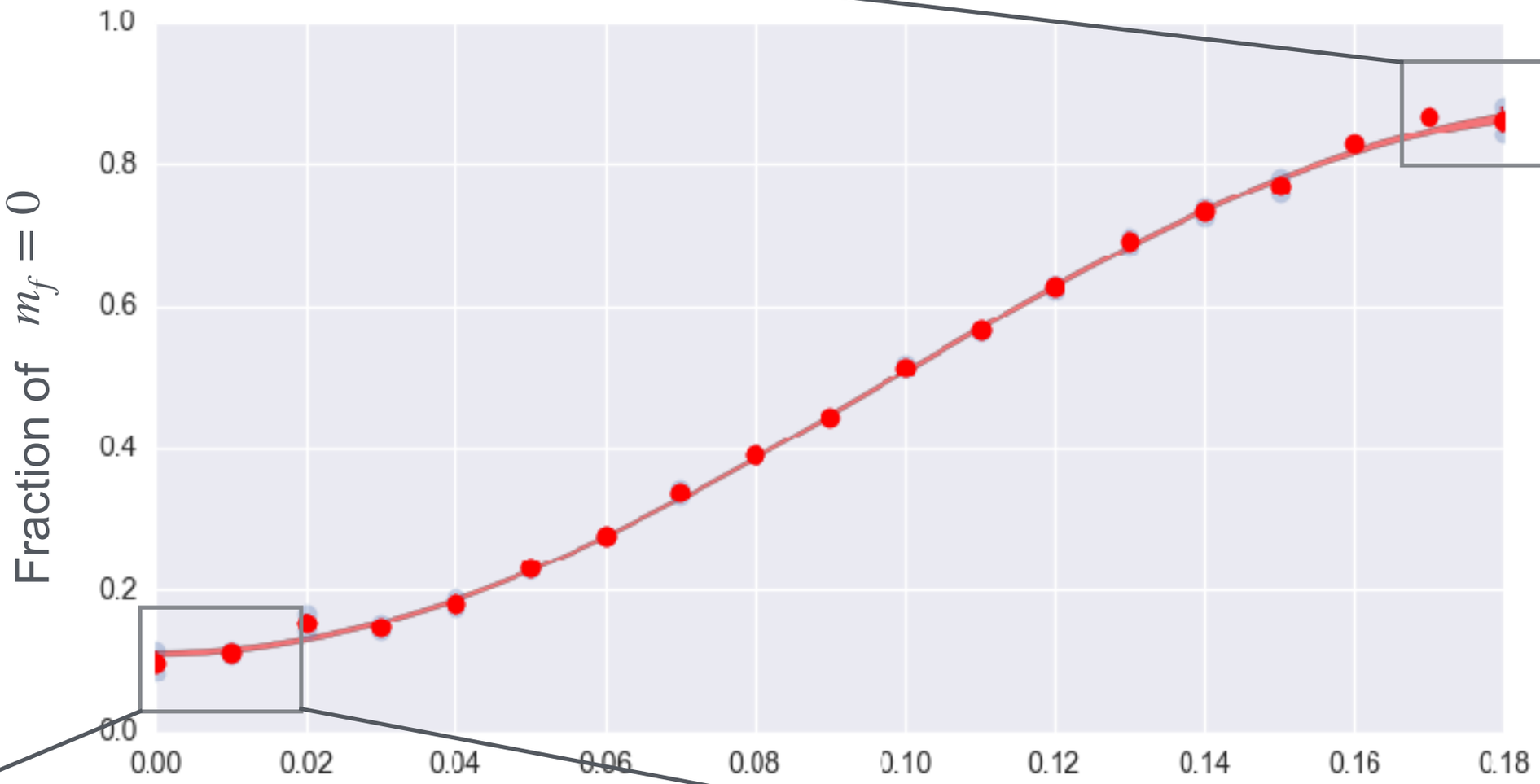


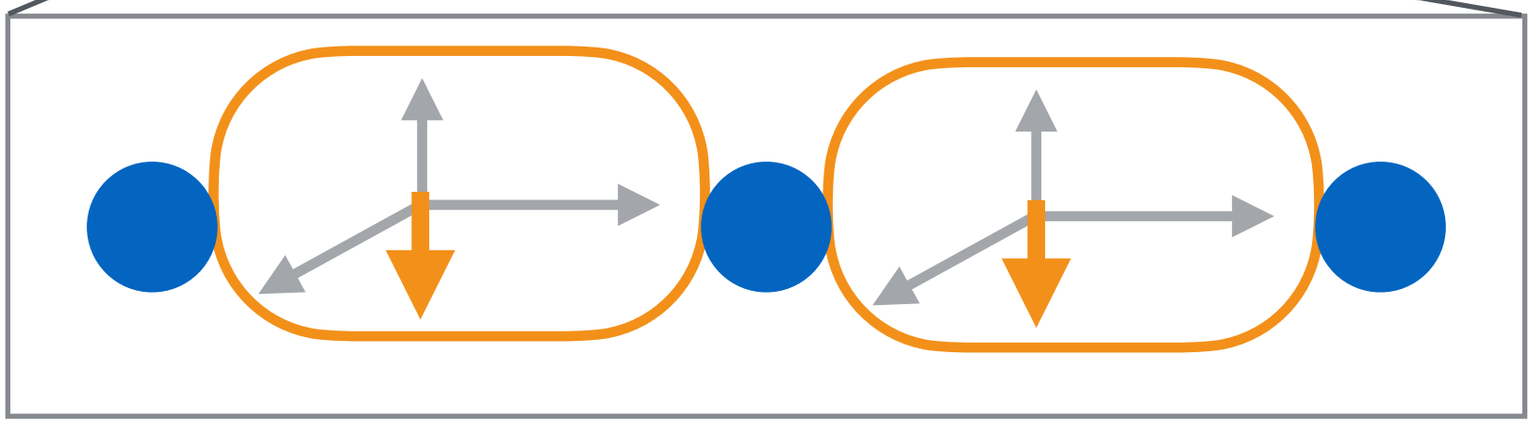
Stern-Gerlach

$m_F = 0$

$m_F = -1$







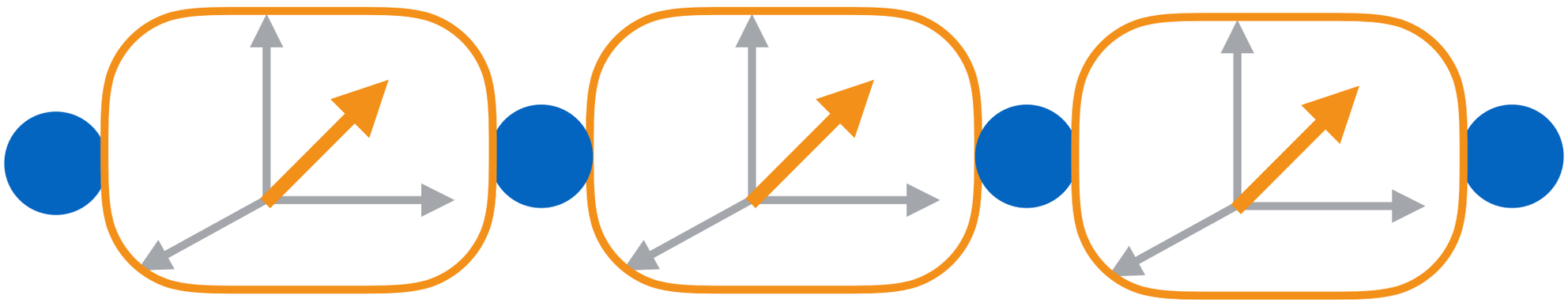
$m_F = 0$

$m_F = -1$

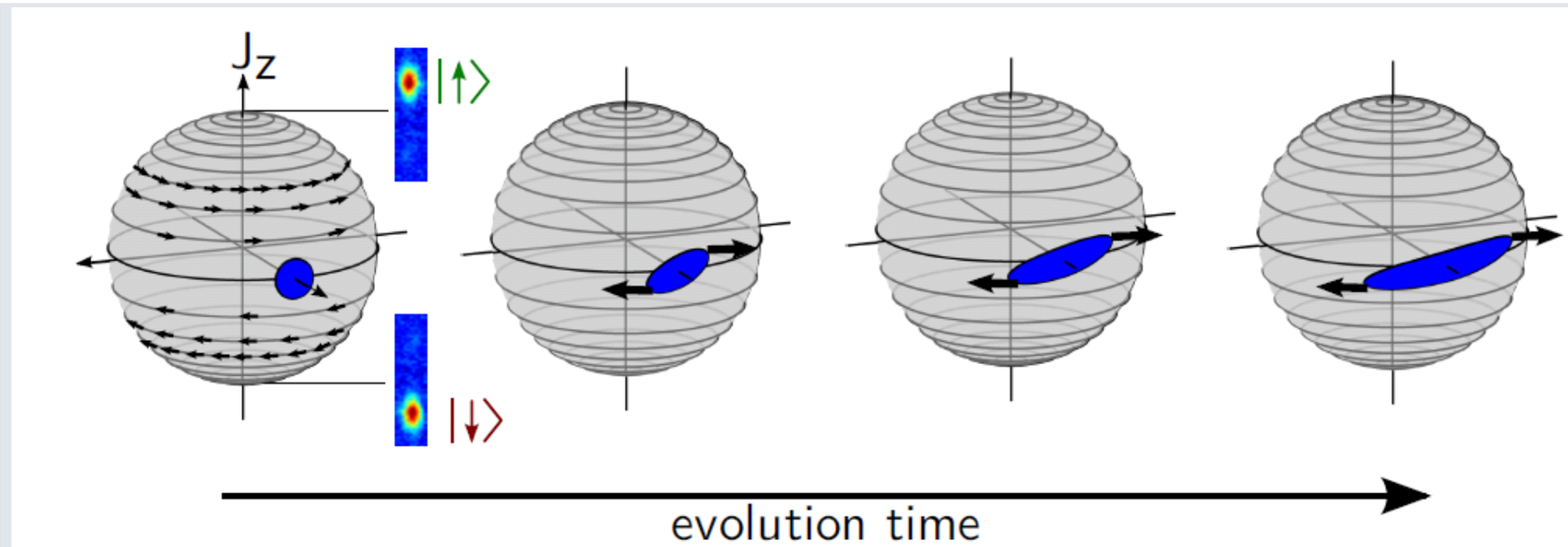
Kasper et al. NJP **19** 023030 (2017)

$$\mathscr{L}_{QED} = \bar{\psi}\left(i\gamma^{\mu}D_{\mu} - m\right)\psi - \frac{1}{4}F^{\mu\nu}F_{\mu\nu}$$

$$H_{KS} = -J\sum_{n}\left(a^{\dagger}_{n+1}L^{+}_{n}a_{n} + a^{\dagger}_{n}L^{-}_{n}a_{n+1}\right) + M\sum_{n}(-1)^{n}a^{\dagger}_{n}a_{n} + \chi\sum_{n}L^{2}_{z,n}$$



One-axis twisting Hamiltonian

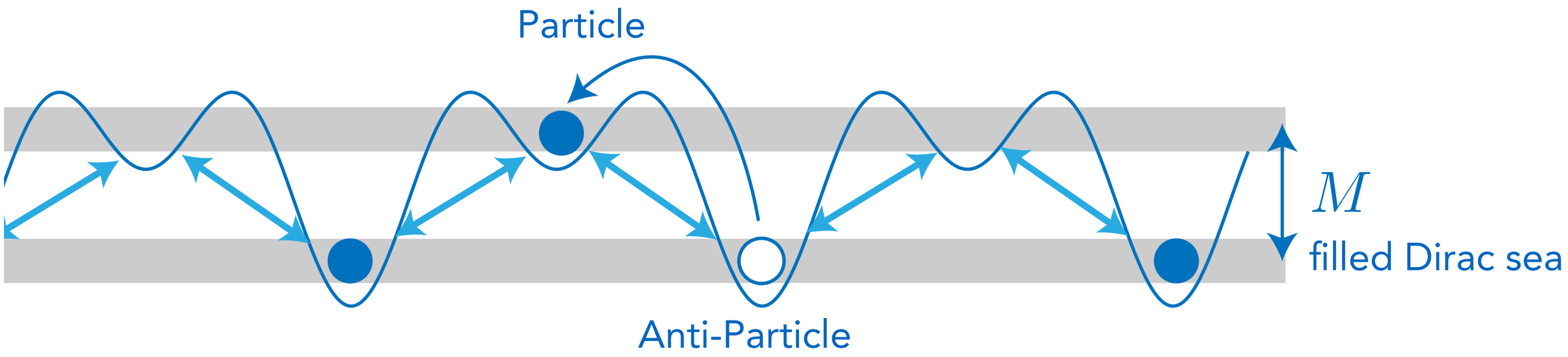


@Oberthaler group, Heidelberg

Kasper et al. NJP **19** 023030 (2017)

$$\mathscr{L}_{QED} = \bar{\psi}\left(i\gamma^{\mu}D_{\mu} - m\right)\psi - \frac{1}{4}F^{\mu\nu}F_{\mu\nu}$$

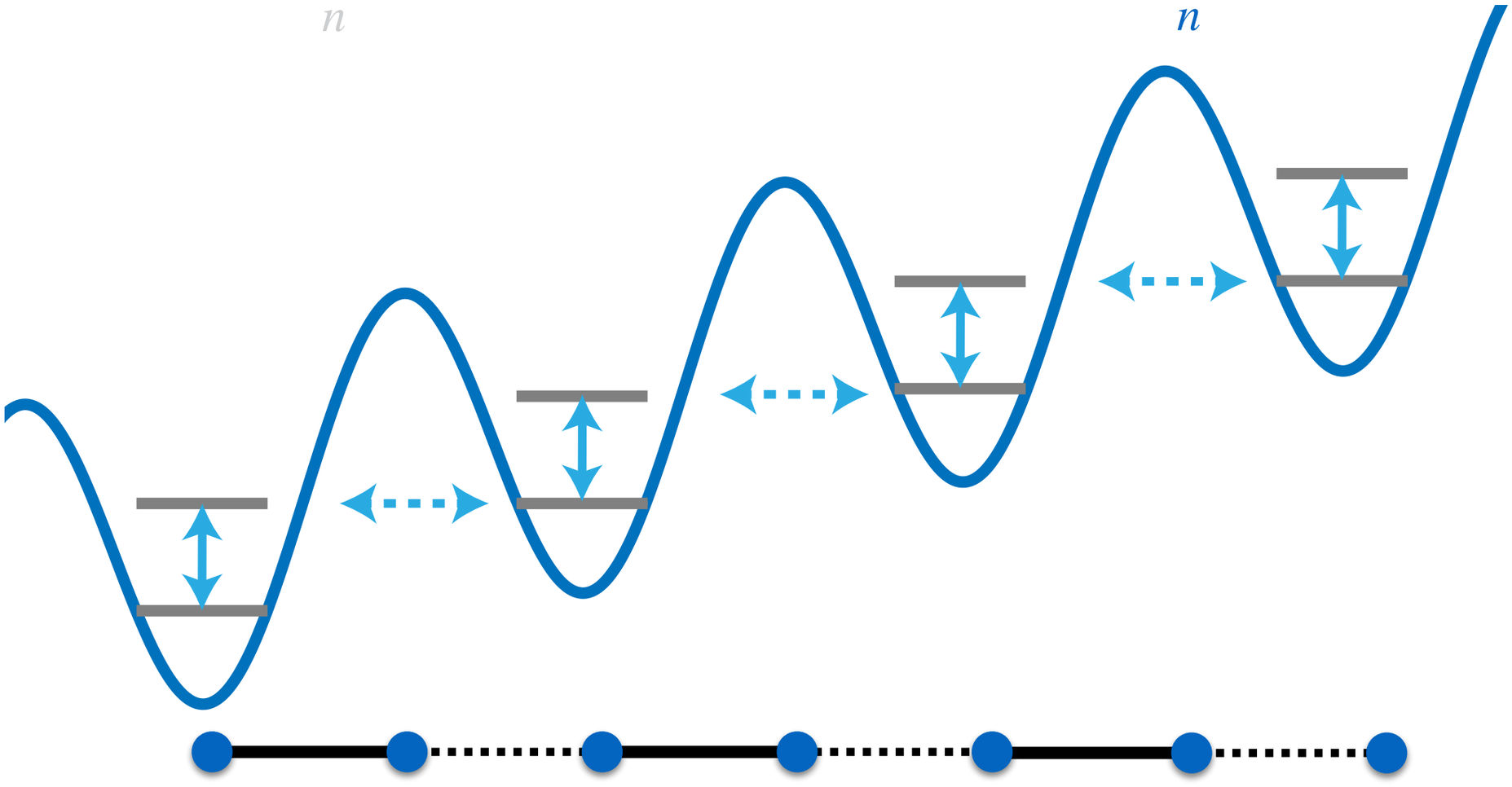
$$H_{KS} = -J\sum_{n}\left(a^{\dagger}_{n+1}L^{+}_{n}a_{n} + a^{\dagger}_{n}L^{-}_{n}a_{n+1}\right) + M\sum_{n}(-1)^{n}a^{\dagger}_{n}a_{n} + \chi\sum_{n}L^{2}_{z,n}$$



Zache et al. Quantum Sci. Technol. **3** 034010 (2018)

$$\mathscr{L}_{QED} = \bar{\psi}\left(i\gamma^{\mu}D_{\mu} - m\right)\psi - \frac{1}{4}F^{\mu\nu}F_{\mu\nu}$$

$$H_{Wilson} = -J\sum_{n}\left(a^{\dagger}_{n+1}L^{+}_{n}a_{n} + a^{\dagger}_{n}L^{-}_{n}a_{n+1}\right) + M\sum_{n}(a^{\dagger}_{n,\uparrow}a_{n,\downarrow} + h.c.) + \chi\sum_{n}L^{2}_{z,n}$$



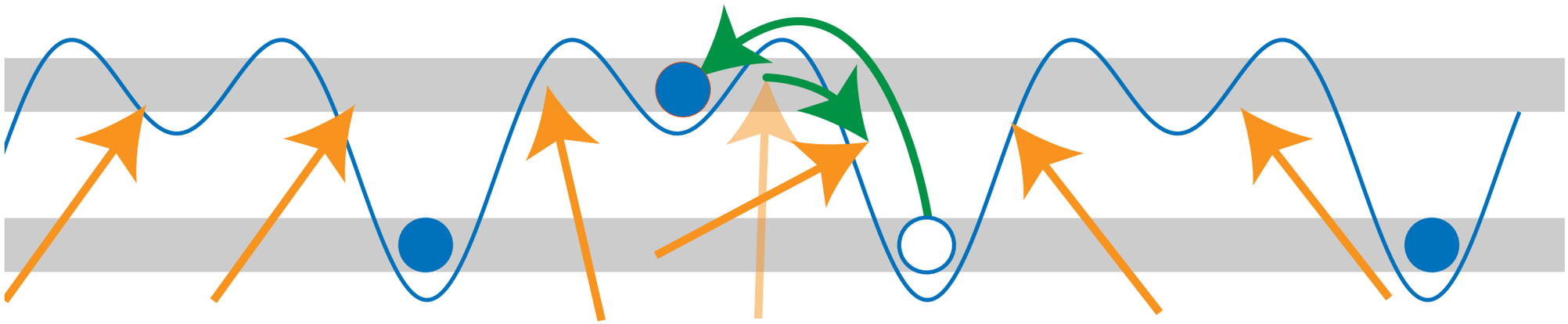
see the talks by Nigel Cooper, Xiong-Jun Liu, Christoph Weitenberg, …

more from the Hauke group in $|0\rangle + \cdots + |n\rangle$ weeks !

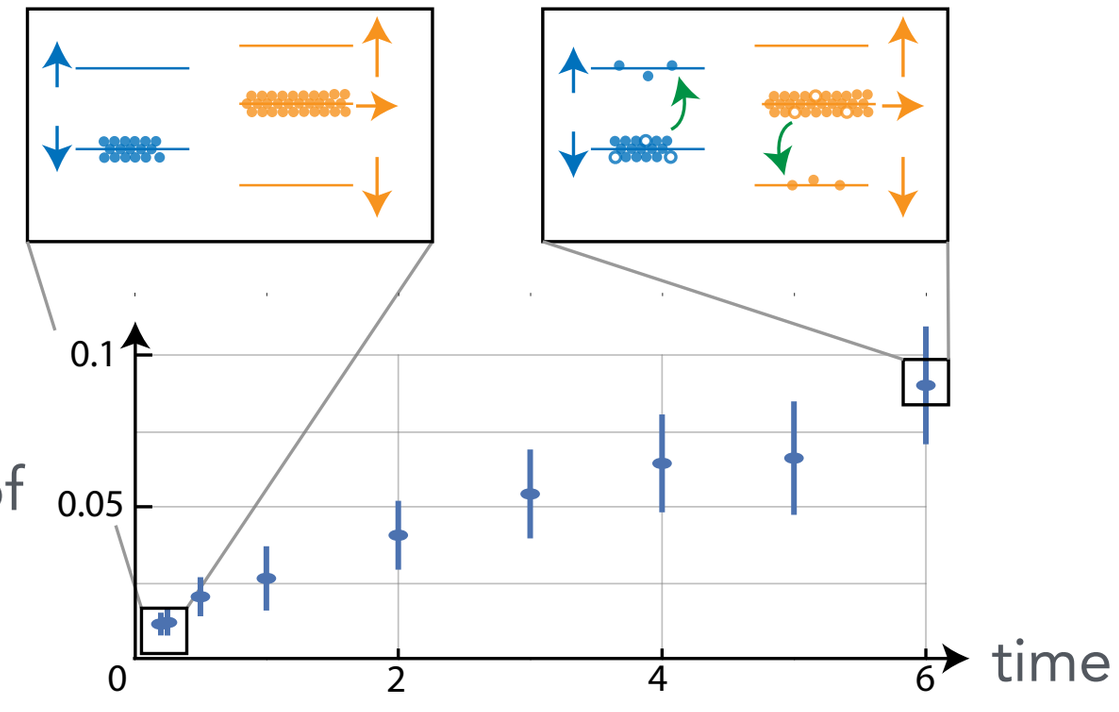
Kasper et al. NJP **19** 023030 (2017)

$$\mathscr{L}_{QED} = \bar{\psi}\left(i\gamma^{\mu}D_{\mu} - m\right)\psi - \frac{1}{4}F^{\mu\nu}F_{\mu\nu}$$

$$H_{KS} = -J\sum_{n}\left(a^{\dagger}_{n+1}L^{+}_{n}a_{n} + a^{\dagger}_{n}L^{-}_{n}a_{n+1}\right) + M\sum_{n}(-1)^{n}a^{\dagger}_{n}a_{n} + \chi\sum_{n}L^{2}_{z,n}$$



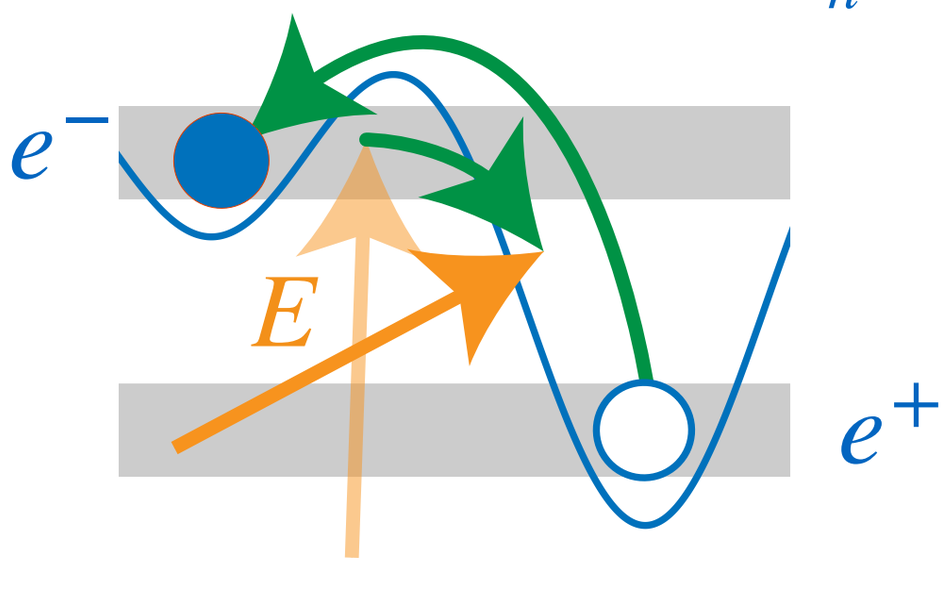
Spin-changing collisions:



PhD of Arno Trautmann

Kasper et al. NJP **19** 023030 (2017)

$$H_{KS} = -J \sum_n \left(a_{n+1}^\dagger L_n^+ a_n + a_n^\dagger L_n^- a_{n+1} \right) + M \sum_n (-1)^n a_n^\dagger a_n + \chi \sum_n L_{z,n}^2$$



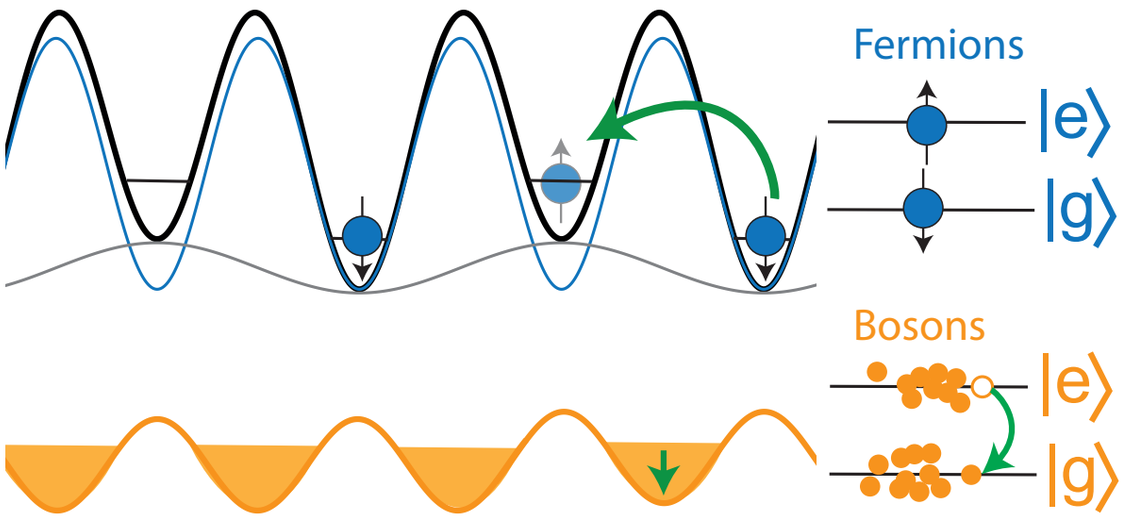
Spontaneous (Schwinger) pair production for large electric fields

$$\chi L_{z,n}^2 > 2M + \chi \left(L_{z,n} - 1 \right)^2$$

$$\chi L_{z,n} > M$$

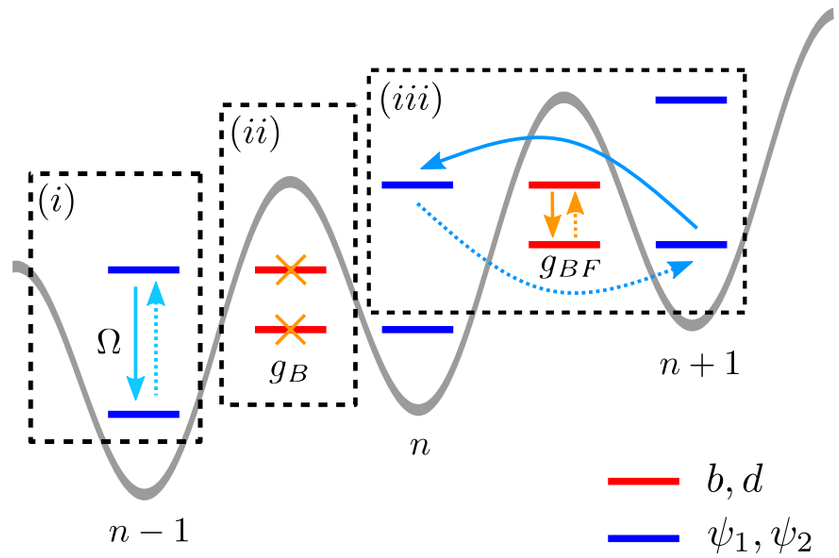
$$\mathcal{L}_{QED} = \bar{\psi}\left(i\gamma^{\mu}D_{\mu} - m\right)\psi - \frac{1}{4}F^{\mu\nu}F_{\mu\nu}$$

Staggered fermions



Kasper et al. NJP **19** 023030 (2017)

Wilson fermions



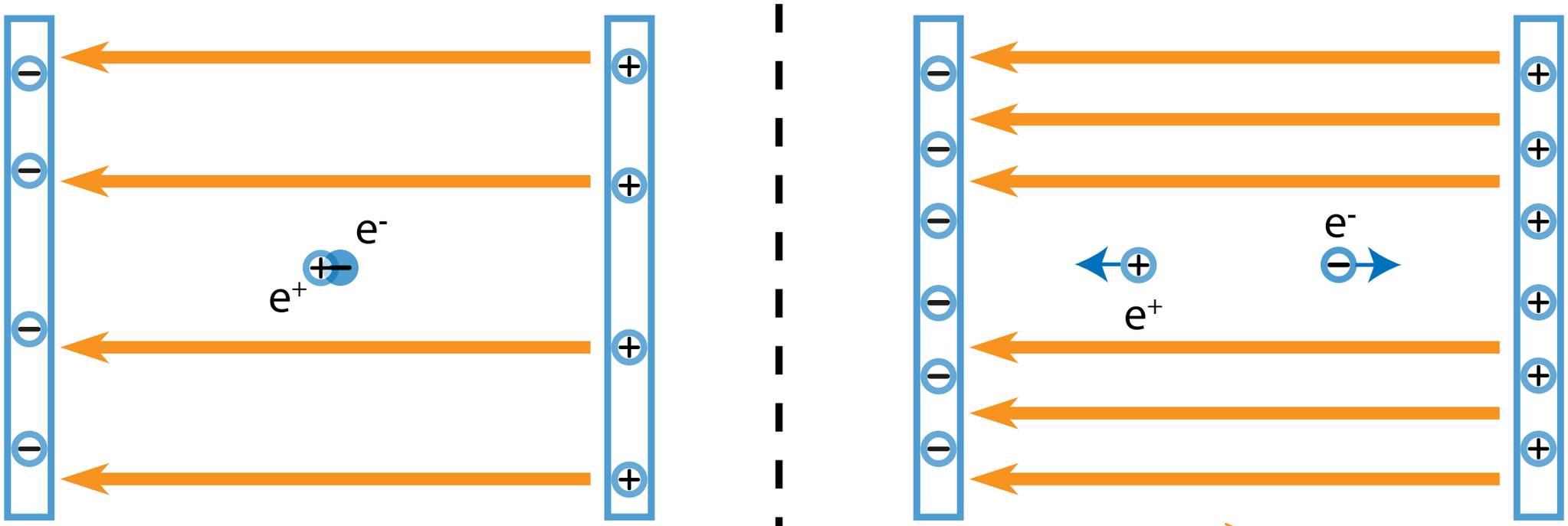
Zache et al. QST **3** 034010 (2018)

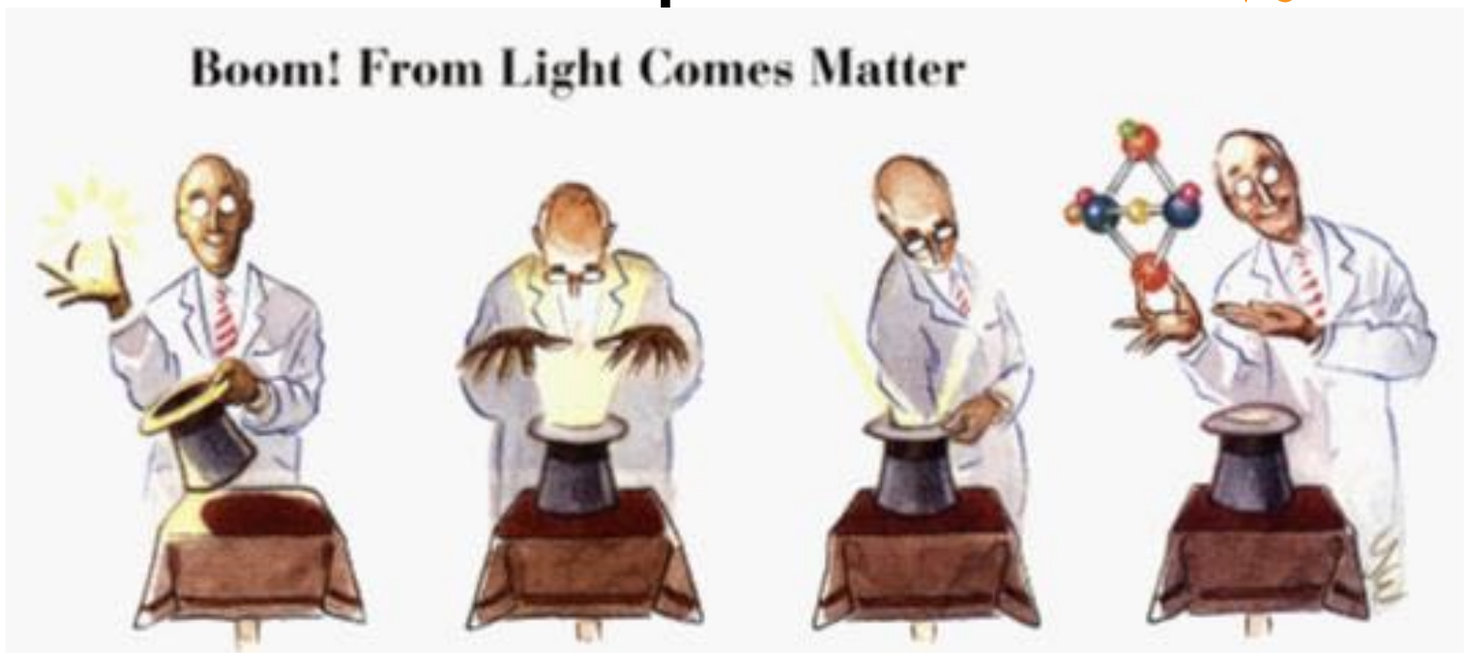
[G. Eisner]

Supplemental slides

Electric vacuum instability

Platform Refrigeration Dyn Gauge Fields





[G. Eisner]

Wiese, Ann. Phys. **525** 777 (2013)
Zohar et al.,Rep. Prog. Phys. **79** 014401 (2016)