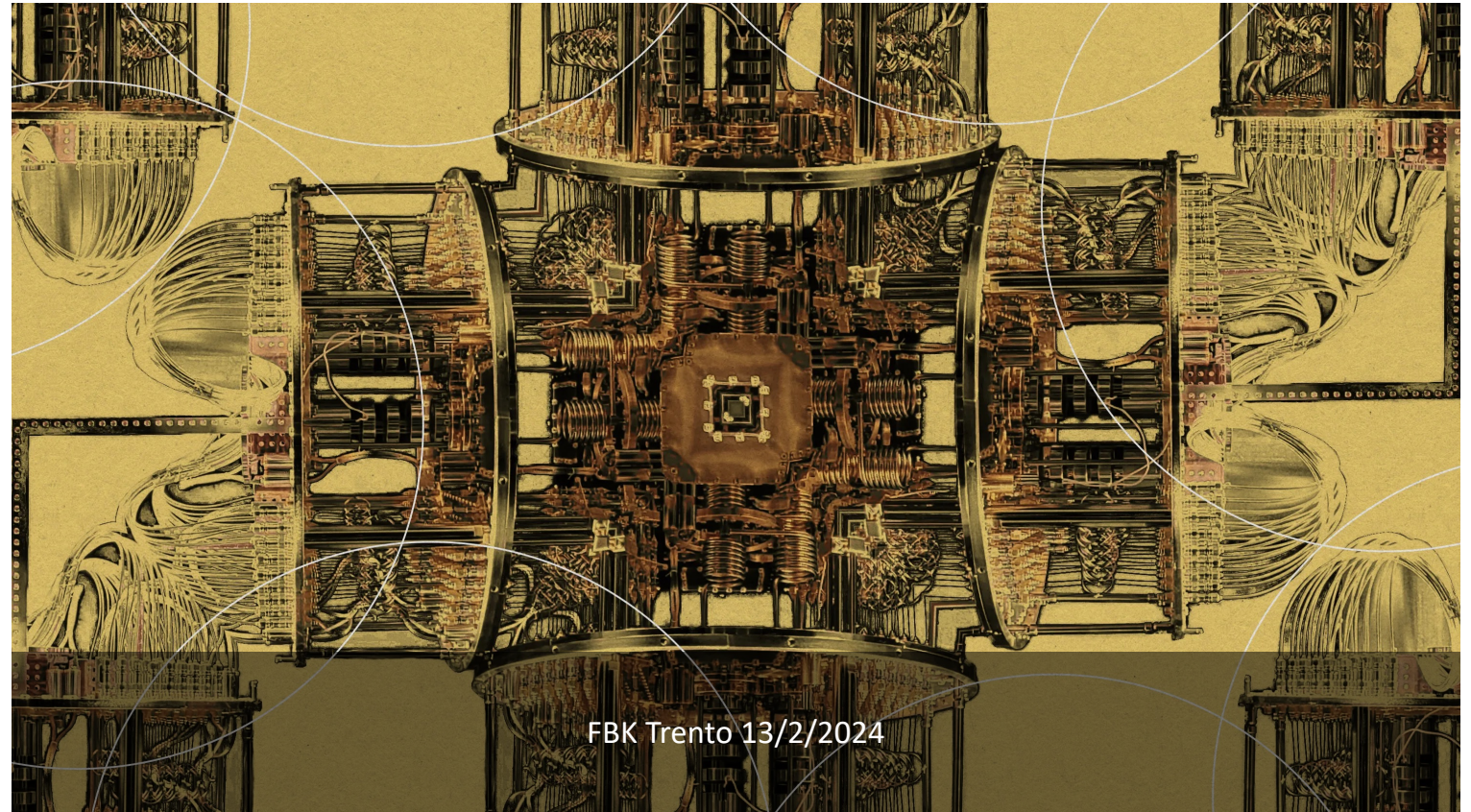



Quantum  
Architectures  
for Analogues  
and Theory  
Applications




FBK Trento 13/2/2024

<https://agenda.infn.it/event/39248/>

<b>Welcome</b>	<i>Richard Hall-Wilton</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	10:00 - 10:05
<b>Introduzione</b>	<i>Claudio Gatti</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	10:07 - 10:12
<b>Attività progettuali trasversali fra Commissione 4 e 5</b>	<i>Alberto Quaranta et al.</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	10:14 - 10:34
<b>Quantum simulation of Hawking radiation and its backreaction in circuit QED devices</b>	<i>Iacopo Carusotto</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	10:36 - 10:51
<b>Quantum Computing with Cavities</b>	<i>Francesco Pederiva</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	10:53 - 11:08
<b>Quantum simulation and non-equilibrium dynamics of the Sachdev-Ye-Kitaev model</b>	<i>Philipp Hauke</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	11:10 - 11:25
<b>Pausa</b>	
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	11:25 - 11:40
<b>Quantum Simulation and Quantum Gravity</b>	<i>Alfredo Iorio</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	11:40 - 11:55
<b>Piattaforma Fotonica</b>	<i>Mirko Lobino</i> 
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	11:57 - 12:12
<b>Piattaforma Superconduttiva</b>	<i>Dr Andrea Giachero et al.</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	12:14 - 12:39
<b>Piattaforma Cold Atoms</b>	<i>Gabriele Ferrari</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	12:41 - 12:56
<b>Software per simulazione e controllo</b>	<i>Alessandro Candido</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	12:58 - 13:13
<b>Algoritmi</b>	<i>Leonardo Banchi</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	13:15 - 13:30

14:00	<b>Pranzo</b>	
	Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	13:30 - 15:00
15:00	<b>Discussione</b>	<i>Claudio Gatti</i>
16:00	Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	15:00 - 17:00

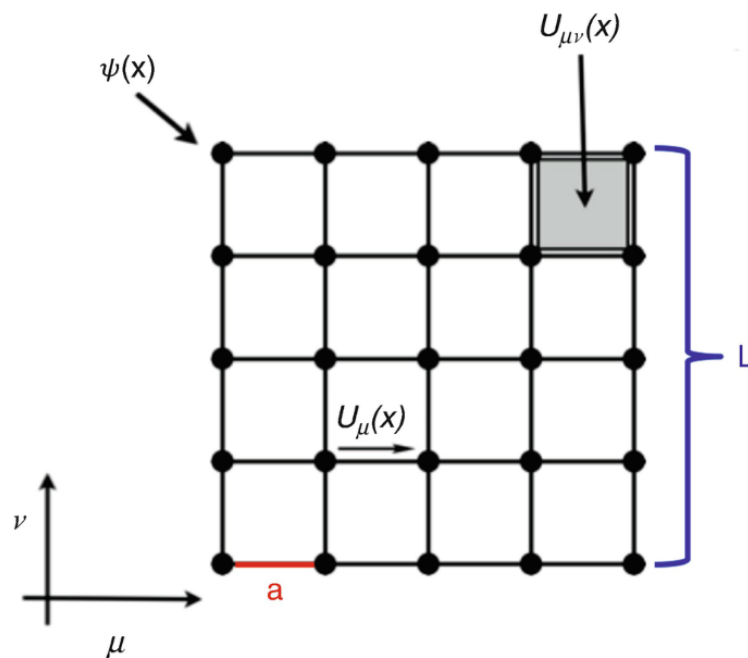
<https://agenda.infn.it/event/39248/>

<b>Welcome</b>	<i>Richard Hall-Wilton</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	10:00 - 10:05
<b>Introduzione</b>	<i>Claudio Gatti</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	10:07 - 10:12
<b>Attività progettuali trasversali fra Commissione 4 e 5</b>	<i>Alberto Quaranta et al.</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	10:14 - 10:34
<b>Quantum simulation of Hawking radiation and its backreaction in circuit QED devices</b>	<i>Iacopo Carusotto</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	10:36 - 10:51
<b>Quantum Computing with Cavities</b>	<i>Francesco Pederiva</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	10:53 - 11:08
<b>Quantum simulation and non-equilibrium dynamics of the Sachdev-Ye-Kitaev model</b>	<i>Philipp Hauke</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	11:10 - 11:25
<b>Pausa</b>	
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	11:25 - 11:40
<b>Quantum Simulation and Quantum Gravity</b>	<i>Alfredo Iorio</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	11:40 - 11:55
<b>Piattaforma Fotonica</b>	<i>Mirko Lobino</i> 
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	11:57 - 12:12
<b>Piattaforma Superconduttiva</b>	<i>Dr Andrea Giachero et al.</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	12:14 - 12:39
<b>Piattaforma Cold Atoms</b>	<i>Gabriele Ferrari</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	12:41 - 12:56
<b>Software per simulazione e controllo</b>	<i>Alessandro Candido</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	12:58 - 13:13
<b>Algoritmi</b>	<i>Leonardo Banchi</i>
Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	13:15 - 13:30

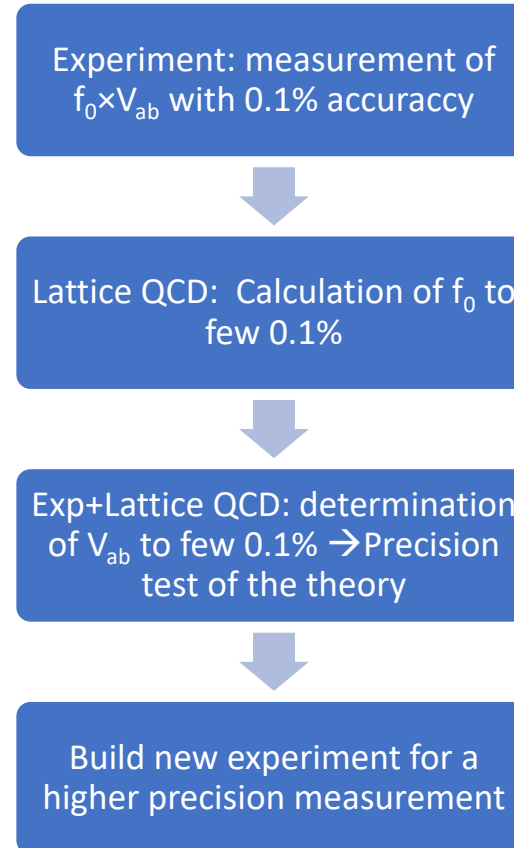
14:00	<b>Pranzo</b>	
	Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	13:30 - 15:00
15:00	<b>Discussione</b>	<i>Claudio Gatti</i>
	in the next pages I show an (incomplete) list of topics to be addressed during the meeting	
16:00	Fondazione Bruno Kessler Via Sommarive, 18, 38123 Povo TN	15:00 - 17:00

# Discussion 1: What can we learn from a (Analogue) Quantum Simulation

What we would like from a simulation:  
The example of Lattice QCD

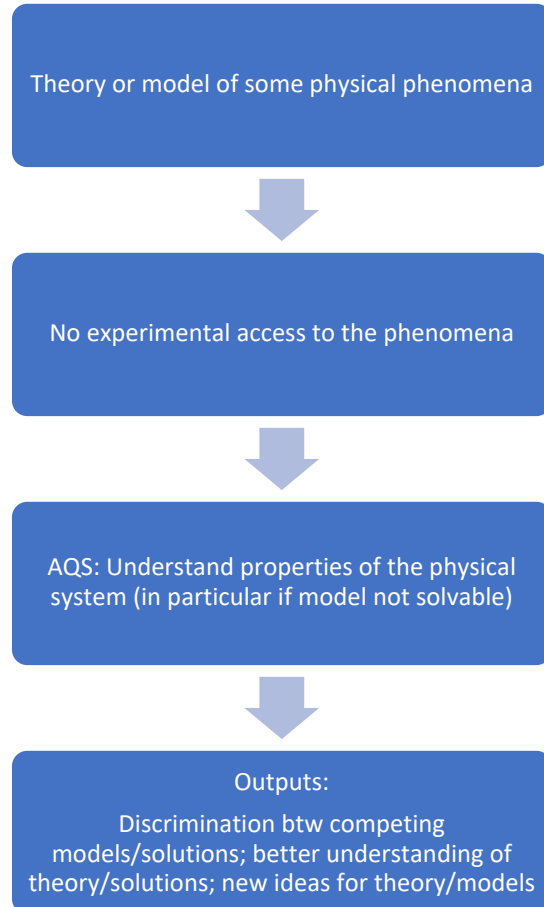


Examples:  $V_{us}$ ,  $g-2$ , B D C mesons decay ratios and constants, alpha strong ...



# Discussion 1: What can we learn from a (Analogue) Quantum Simulation

*How does the study of analogue systems provides information for better understanding of the physics phenomenon?*



# Discussion 2: How to realize the (A)QS?

Theory/model

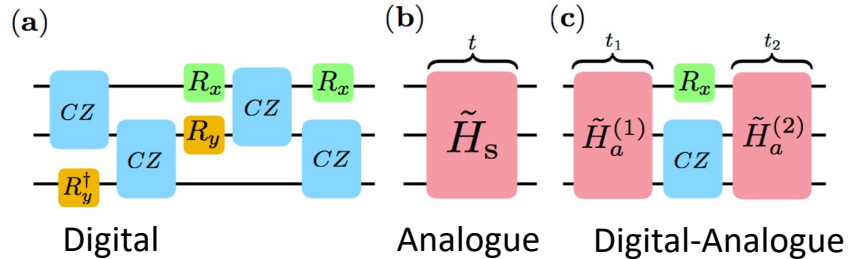
$$i\gamma^a e_{(a)}^\mu \partial_\mu \psi + \frac{i}{2} \gamma^a \frac{1}{\sqrt{-g}} \partial_\mu (\sqrt{-g} e_{(a)}^\mu) \psi - m\psi = 0,$$



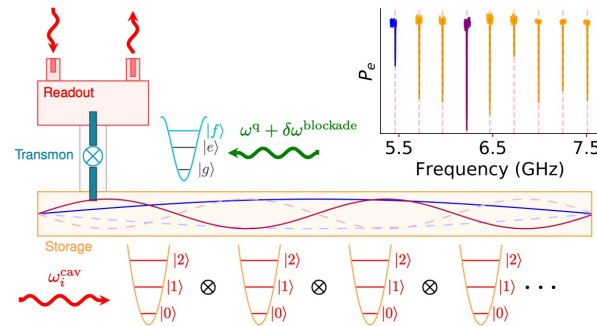
Mapping

Theory/model in Lab “operator space”

$$\hat{H} = - \sum_j \kappa_j (\hat{\sigma}_j^+ \hat{\sigma}_{j+1}^- + \hat{\sigma}_j^- \hat{\sigma}_{j+1}^+) - \sum_j \mu_j \hat{\sigma}_j^+ \hat{\sigma}_j^-$$

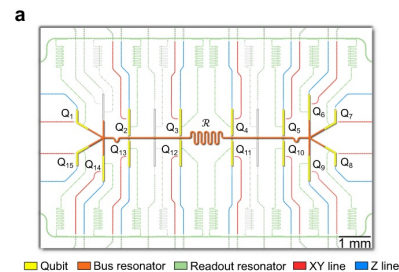


Qudits and QOC

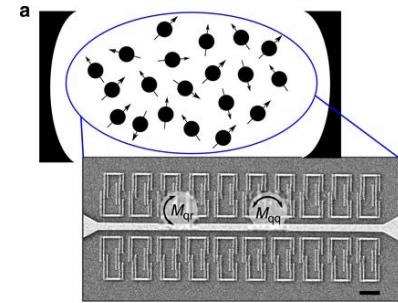


Analogue circuit realization

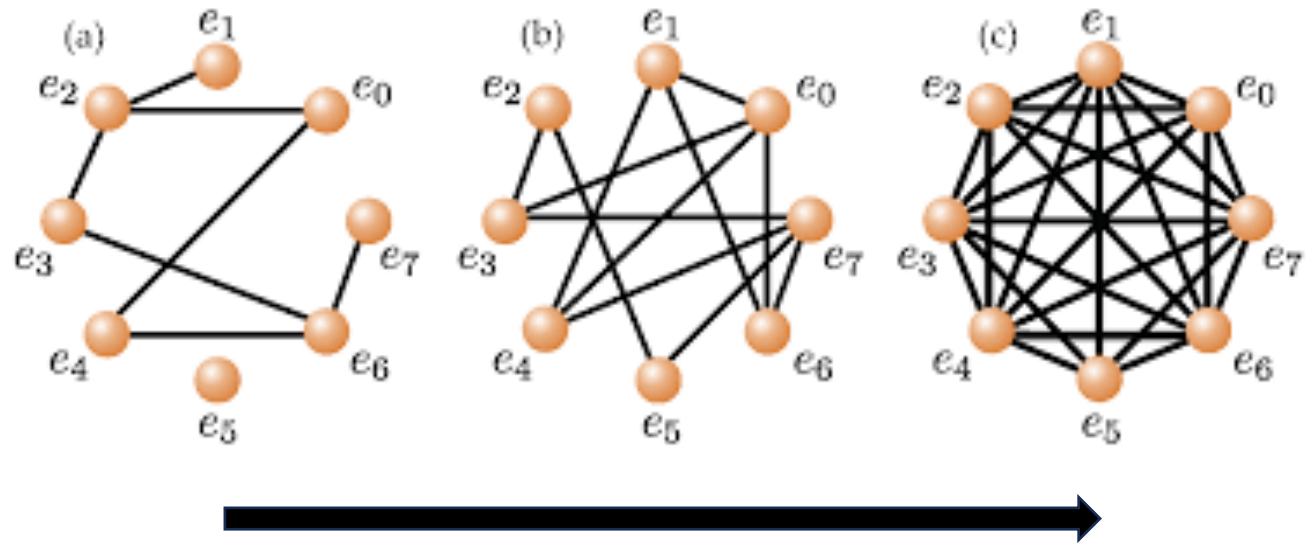
Multiple qubits entangling gates



Metamaterials

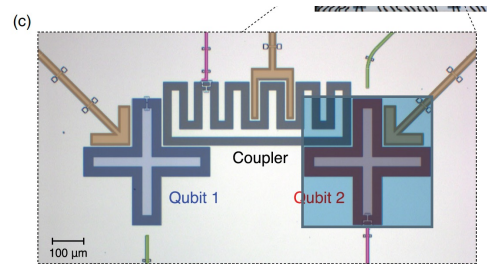
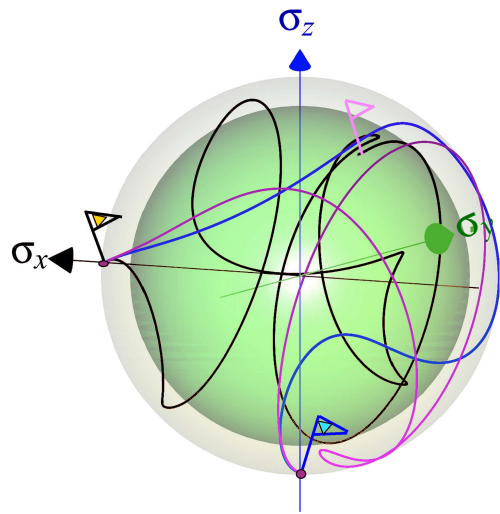
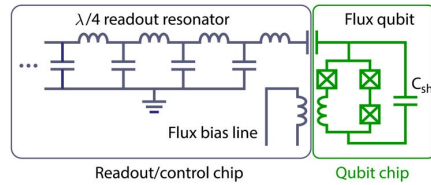
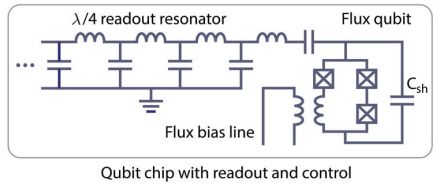
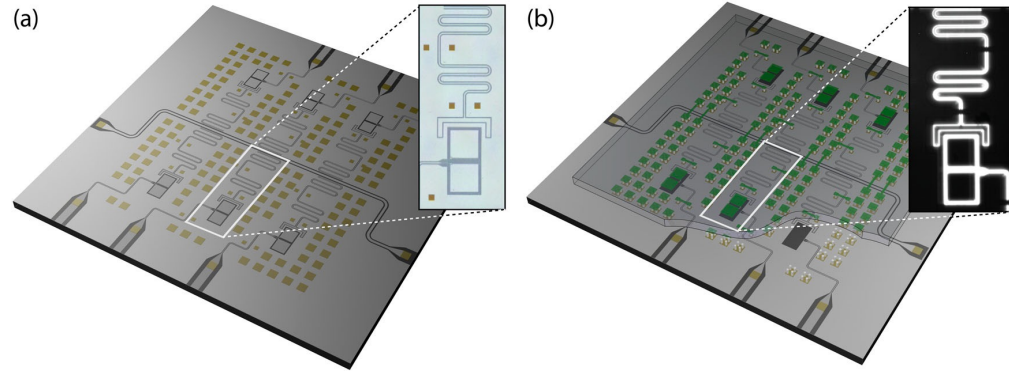


Discussion 3:  
How big  
must be  $N$ ?



How to scale to a large enough system?

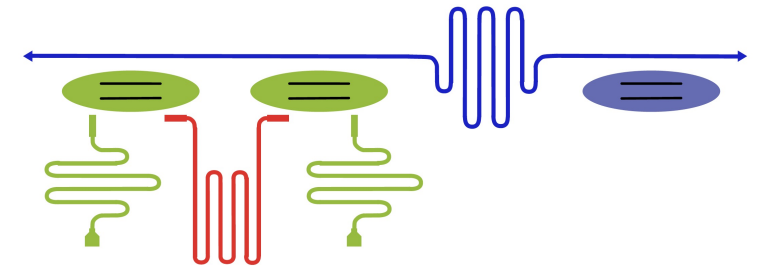
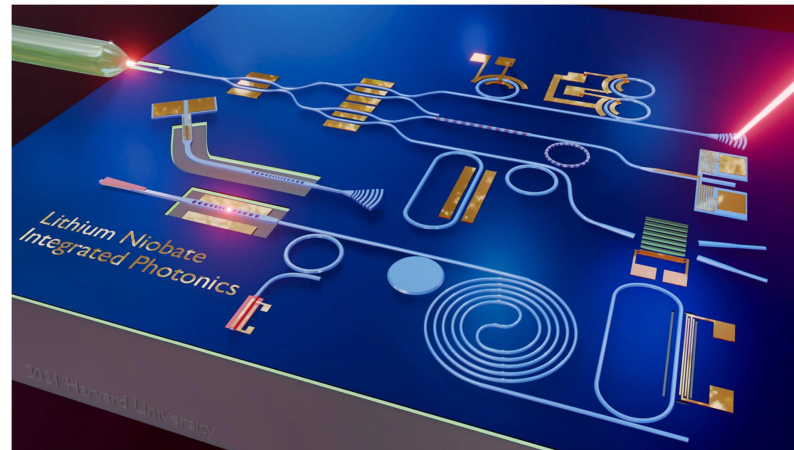
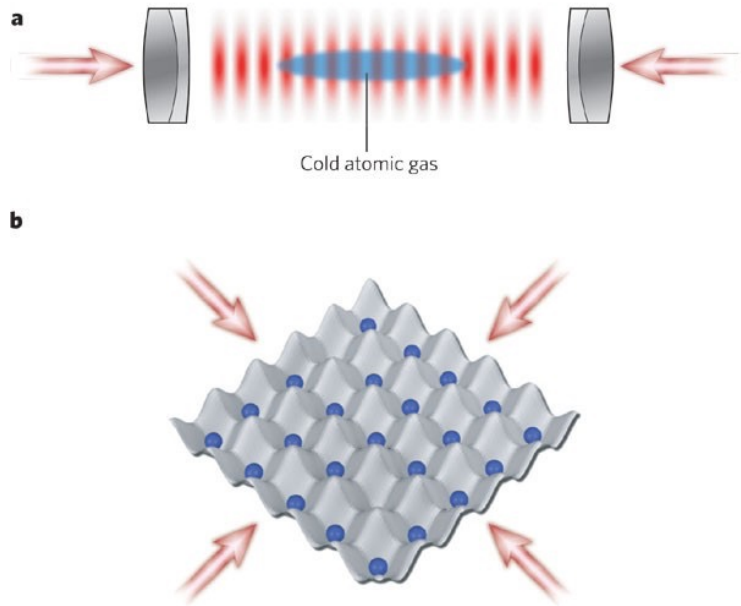
# Discussion 4: Key Enabling Technologies for AQS?



- Pulse generation for QOC
- Flip chip process
- Tunable couplers
- Multiqubit gates
- Qudits
- Optimization algorithms



# Discussion 5: Platforms, pros and cons.



# Discussion 6: Project Organization

