SMQ* Vocabulary Quick Reference Guide

Terms	Relevant Definition	Introduced (Week)
Accelerator	A machine which can accelerate tiny particles to speeds near the speed of light; a machine that moves particles towards high energies	1, 4, 9
AC electromagnetic radiation	Electromagnetic Radiation: Alternating current (AC) electromagnetic radiation refers to time-varying electric and magnetic fields that propagate through space. It encompasses a range of frequencies, including radio waves, microwaves, infrared, visible light, and beyond.	4
ADR	A specialized type of refrigerator to reach extremely cold temperatures (I don't think students should be looking this one up beforehand - we'll try to explain it in the lecture)	9
AFM Imaging	Atomic Force Microscope - Technique used to hone in on surface of a sample; used to measure the topography of a sample	4
Anti-matter	Matter composed of the antiparticles (or "partners") of the corresponding particles in "ordinary" matter	1
BCS Theory	Bardeen-Cooper-Schrieffer (BCS) theory is a fundamental explanation of superconductivity, describing how electrons form bound pairs (Cooper pairs) at low temperatures, allowing for resistance-free electrical flow.	4
Cavities	In the context of superconducting radiofrequency (SRF) and quantum systems, cavities are resonant structures that confine electromagnetic fields, enhancing interactions between radiation and materials for applications such as particle accelerators and quantum computing.	4

Classical v. Quantum state	Classical vs. Quantum - the main fundamental difference between classical and quantum physics is that in quantum physics the outcomes of an experiment are probabilistic, with the probabilities for each different outcome being determined by the Schrodinger's equation. Meanwhile, in classical physics the outcome of an experiment is uniquely determined by Newton's Laws.	3
Coherence	Coherence refers to the preservation of a well-defined phase relationship in a quantum system over time, which is crucial for maintaining quantum states in qubits and preventing decoherence. The ability of a physical system to maintain its state. In a coherent state, quantum states are defined and exhibit predictable behavior. Coherence time is the time in which a quantum system maintains the coherence. In quantum computing, coherence time is an important metric to define the length and complexity of algorithms that can be executed within this time.	2, 4
Cooper Pairs	Cooper pairs are pairs of electrons that, due to lattice interactions in a superconductor, move in a correlated fashion without resistance, forming the basis of superconductivity as described by BCS theory.	4
Cosmos	Physical universe	1
Cryogenics:	Basically, the study of achieving temperatures below 150 Kelvin	9
Cryptography	The practice of encoding a message that can only be read by the intended receiver. Quantum algorithms are particularly suitable for cryptography.	2
Dark Energy	A theoretical intense force that counteracts gravity and causes the universe to expand at an increased rate	1

Dark Matter	A hypothetical form of matter that is invisible; does not interact with light but is inferred to exist due to its gravitational effects on visible matter.	1
Decoherence	The process by which a quantum system loses its quantum properties due to interactions with its environment, causing superpositions to collapse, leading to the degradation of quantum information. The process by which a quantum system loses its state and begins behaving classically.	2, 4, 6
Degeneracy state	Multiple states separated by the same energy spacing	4
Electromagnetic	Relating to electric and magnetic fields, typically referring to waves that propagate through space, such as radio waves, microwaves, and visible light.	4
Entanglement	Quantum entanglement is the phenomenon of a group of particles being generated, interacting, or sharing spatial proximity in a manner such that the quantum state of each particle of the group cannot be described independently of the state of the others, including when a large distance separates the particles. Under certain conditions a pair of subatomic particles can become connected in a specific way that allows each particle to know the state of the other no matter how separated they are. If we observe a certain property of one particle, we will know exactly the value of that property for the other particle.	2, 3
Forces	The fundamental interactions that govern the motion of celestial (e.g., in the sky) objects	1
Fundamental Physics Theory	Fundamental Physics Theory - a mathematical framework of the behavior of fundamental particles that tries to model the phenomena observed in experiments.	3
g-2	Fermilab's muon g-2 experiment made the world's most precise measurement of the anomalous magnetic moment of the muon.	1
Higgs boson	A fundamental particle in the Standard Model; a subatomic particle that gives mass to other particles in the universe.	1

Kelvin	A temperature scale similar to Celsius	9
Large Hadron Collider (LHC)	A massive particle accelerator located near Geneva, Switzerland (CERN) where scientists smash subatomic particles together at near light-speed to explore the fundamental building blocks of matter.	1
Leptons	Elementary particles that are not affected by the strong nuclear force; They are only affected by the weak nuclear force, gravitational force, and electromagnetic force.	1
LNG	Liquified Natural Gas, a type of fuel somewhat similar to gasoline, except it is stored in its liquid state, meaning that it is generally cold.	9
Magnetic moment	Refers to the strength and orientation of a celestial object's magnetic field; a vector quantity having both magnitude and direction of the magnetic field generated by an astronomical body - due to the movement of charged particles within it.	1
Matter	Solids, liquids, plasma, and gases; any substance that has mass and occupies space.	1
MRI	Magnetic Resonance Imaging, a type of medical imaging technique used to generate images of human internals which greatly aids doctors in assisting patients in need of help. Signals acquired through magnetic resonance are analyzed to reconstruct the imaging. High computing power is needed to increase the resolution.	2, 9
Muons	A fundamental subatomic particle, similar to but heavier than an electron and is produced when Cosmic rays interact with the earth's atmosphere.	1

Nanofabrication		6
NbSRF cavity		4
Neutrino	A tiny, nearly massless subatomic particle that rarely interacts with matter;.	1
Neutrino oscillations	Quantum mechanical phenomenon where a neutrino can change its flavor (e.g., electron, muon, or tau) as it travels through space.	1
Oscillate	Rhythmic expansion or contraction of a star's outer layer.	1
Particle exchange	The concept where fundamental forces between particles are mediated by the exchange of vertical particles (acting as messengers between particles).	1
Particle-wave Duality	Particle-Wave Duality - at the subatomic scale waves (such as light) can exhibit particle-like behavior, and particles (such as electrons) can exhibit wave-like behavior. Whether wave or particle-like behavior is shown depends on the experiment being carried out.	3
Photon	A particle representing a quantum of light or other electromagnetic radiation. A fundamental particle of light and electromagnetic radiation, carrying energy proportional to its frequency, and playing a key role in quantum mechanics and quantum information processing.	2, 4
Physics	The study of matter and its interactions.	1
Quantum	Studying the smallest possible unit of something; A term referring to the principles of quantum mechanics, which govern the behavior of particles at extremely small scales, where properties such as superposition and entanglement become significant.	1, 2, 3, 4

Quantum gate	A basic quantum circuit that operates on a small number of qubits, they are the building blocks for quantum circuits, just like how classical logic gates are for standard digital circuits. These basic quantum gates have already been made in laboratories.	3
Quantum mechanics (traditional)	Wave function, quantum computing, cryptography	1
Quantum Sensing	Measuring something with maximum possible sensitivity, limited by quantum mechanics	4, 6
Quantum teleportation	Quantum teleportation is a technique for transferring quantum information from a sender at one location to a receiver some distance away.	2
Quarks	Elementary particles that combine to form protons and neutrons, the building blocks of atomic nuclei.	1
Qubits (Also known as quantum bit)	Quantum Bit (QuBit). The logic unit of quantum computers can also refer to physical systems; for example, transmon qubits are a particular type of superconducting qubits. Fundamental units of information that can exist simultaneously in multiple states. Quantum bits, or qubits, are the fundamental units of quantum information, capable of existing in superpositions of 0 and 1, enabling quantum computing advantages over classical bits.	2,3, 4, 6
Relativistic quantum mechanics	A physics theory that is refers to quantum mechanics applied with special relativity	1
RF	Radio frequency; Electromagnetic waves in the frequency range typically from kilohertz (kHz) to gigahertz (GHz), used in communication, particle accelerators, and quantum devices.	4
Standard Model	It looks like a Periodic Table; provides a way to classify known elementary particles (i.e., Fermions and bosons)	1
SRF	Superconducting radio frequencies; a technology that uses superconducting materials to construct high-quality resonant cavities for efficient RF electromagnetic field confinement, widely used in accelerators and quantum applications.	4, 6

Superconducting	A state of certain materials at low temperatures where they exhibit zero electrical resistance and expel magnetic fields, enabling applications such as SRF cavities and quantum computing.	3, 6
Superconducting qubits	Quantum bits that utilize superconducting circuits to store and manipulate quantum information; the "brain" on circuits that are fabricated on chips	6
Superposition	A quantum state can be represented as the superposition of two or more states, each happening with some probability. A fundamental principle of quantum mechanics where a quantum system exists in multiple states simultaneously until measured, enabling quantum computing's computational power.	2, 3, 4
Thermodynamics	A field of study concerning the relationships between heat and other forms of energy such as mechanical, electrical or chemical and how this energy is transferred from one form to another and/or from one location to another.	9
Transition temperature, T	Critical temperature	4
Tunneling	Teleportation analogy	4
Ultra-sensitive	Refers to the ability of a system, sensor, or device to detect extremely small signals or changes, often used in the context of quantum measurement and precision experiments.	4
Uncertainty Principle	If a particle is moving over a trajectory, the velocity and position cannot be known simultaneously with infinite precision. This is defined by the equation $\Delta x \, \Delta p \geq \hbar/2$, where x is the position, p=mv is the momentum, m is the mass of the particle, and v is the velocity of the particle. $\hbar/2$ is a very small number depending on h, which is the Plank constant.	2