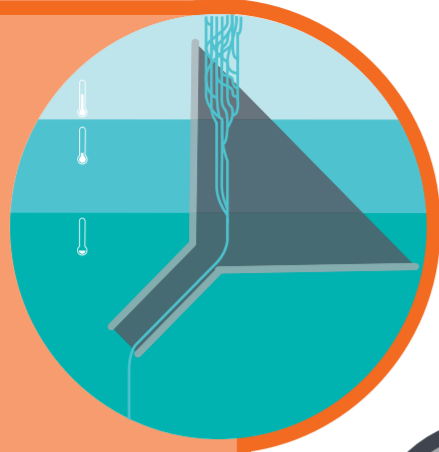


### The discovery of superfluidity

Don Misener, John Allen et Piotr Kapitsa discovered the superfluidity. When helium is cooled enough to nearly reach the absolute zero, it becomes a fluid with zero viscosity. All the atoms, which are bosons, coalesce to form a **condensate**.



It's a liquid form of a Bose-Einstein condensate.

1938

### The laser cooling

That experience developed by Steven Chu, William Philips and Claude Cohen Tannoudji (Nobel prize 1997) was crucial in the Bose-Einstein condensate's accomplishment in enabling very efficient atom cooling.

1985  
1990

NOBEL PRIZE  
2001

# BOSE-EINSTEIN CONDENSATE

### Doppler laser cooling

The first cooling technique used is the laser cooling :

Six laser beams are targeting each atom.

The absorption and emission of photons reduces the speed of the atom. Since the temperature of a group of atoms is due to its kinetic energy, this technique greatly **cools down** atoms. However it is not enough to obtain a Bose-Einstein Condensate.

Doppler cooling

### Evaporative cooling

Afterwards atoms are placed in a magnetic trap.

The colder atoms place themselves at the bottom while the most excited ones go upwards. Then one reduces the depth of the magnetic trap which leads the **warmer** (and so the most energetic) **atoms to leave the trap near**, allowing us to keep only the cold ones. Once the temperature is very near the absolute zero, **particles bound together suddenly!**

Evaporative cooling

Effects

1995

Production of the first Bose-Einstein Condensate



Carl Wieman



Wolfgang Ketterle



Eric Cornell

1990

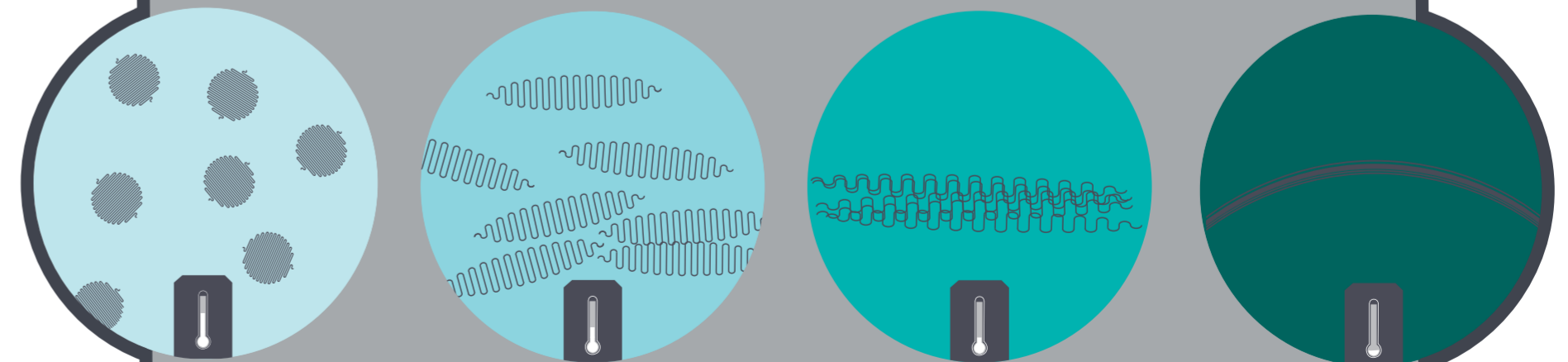
Eric Cornell start to work with Carl Wieman in his laboratory

### Wavelengths enlargement

One of the basic properties of quantum physics is **wave-particle duality**. Thanks to the two processes mentioned above, one is able to gradually cool down the particles very close to absolute zero. During the chilling process the speed of the particles decreases in opposition with his **wavelength which hence increases**.

Near the absolute zero these wavelengths will overlap and merge to form an **unique huge quantum wave**.

This is the Bose-Einstein Condensate.



World War II  
1939  
1945

Neil armstrong stepped onto lunar surface  
1969

1989  
The fall of Berlin Wall

Wolfgang Ketterle's birth  
1957

1951  
Carl Wieman's birth

1925

### The theory of the condensate

Satyendra Nath Bose discovered **bosons**. These particles are able to occupy a common unique quantum state, unlike particles such as electrons. Since he was unrecognized by the scientific community, Satyendra Bose sent a letter to **Albert Einstein**, who helped him to publish his article. Afterward, Einstein proposed the hypothesis that all the bosons of a gaz, once sufficiently cooled, could take a unique physical state. It is called the **Bose-Einstein condensate** ! This condensate will be produced only 75 years later.

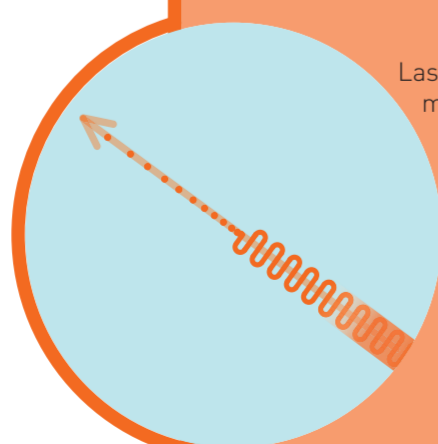


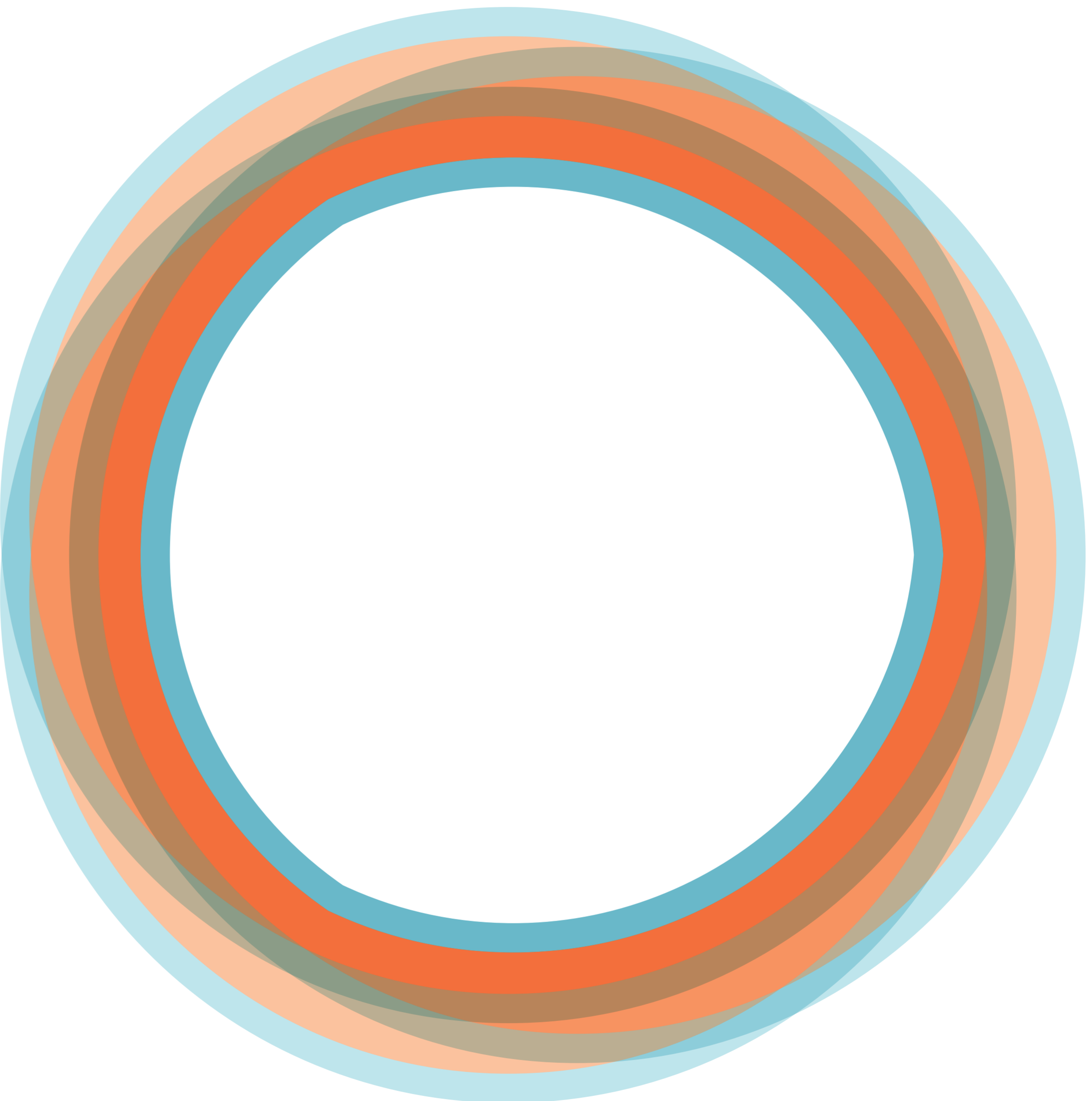
1958

### The laser's invention

This technique uses quantum characteristics to create a very pure and directional beam.

Lasers led to many innovations including laser cooling.





NOBEL PRIZE



2001

BOSE-EINSTEIN  
CONDENSATE

