= topness , B ? =
bottomness .
* Notation such as 173210 ± 510 ± 710 denotes two types of measurement uncertainty . In the case of the top quark , the first uncertainty is statistical in nature , and the second is systematic .

= = Interacting quarks = =

As described by quantum chromodynamics , the strong interaction between quarks is mediated by gluons , massless vector gauge bosons . Each gluon carries one color charge and one anticolor charge . In the standard framework of particle interactions (part of a more general formulation known as perturbation theory) , gluons are constantly exchanged between quarks through a virtual emission and absorption process . When a gluon is transferred between quarks , a color change occurs in both ; for example , if a red quark emits a red ? antigreen gluon , it becomes green , and if a green quark absorbs a red ? antigreen gluon , it becomes red . Therefore , while each quark 's color constantly changes , their strong interaction is preserved .

Since gluons carry color charge , they themselves are able to emit and absorb other gluons . This causes asymptotic freedom : as quarks come closer to each other , the chromodynamic binding force between them weakens . Conversely , as the distance between quarks increases , the binding force strengthens . The color field becomes stressed , much as an elastic band is stressed when stretched , and more gluons of appropriate color are spontaneously created to strengthen the field . Above a certain energy threshold , pairs of quarks and antiquarks are created . These pairs bind with the quarks being separated , causing new hadrons to form . This phenomenon is known as color confinement : quarks never appear in isolation . This process of hadronization occurs before quarks , formed in a high energy collision , are able to interact in any other way . The only exception is the top quark , which may decay before it hadronizes .

= = = Sea quarks = = =

Hadrons contain , along with the valence quarks (q
v) that contribute to their quantum numbers , virtual quark ? antiquark (qq) pairs known as sea quarks (q
s) . Sea quarks form when a gluon of the hadron 's color field splits ; this process also works in reverse in that the annihilation of two sea quarks produces a gluon . The result is a constant flux of gluon splits and creations colloquially known as " the sea " . Sea quarks are much less stable than their valence counterparts , and they typically annihilate each other within the interior of the hadron . Despite this , sea quarks can hadronize into baryonic or mesonic particles under certain circumstances .

= = = Other phases of quark matter = = =

Under sufficiently extreme conditions , quarks may become deconfined and exist as free particles . In the course of asymptotic freedom , the strong interaction becomes weaker at higher temperatures . Eventually , color confinement would be lost and an extremely hot plasma of freely moving quarks and gluons would be formed . This theoretical phase of matter is called quark ? gluon plasma . The exact conditions needed to give rise to this state are unknown and have been the subject of a great deal of speculation and experimentation . A recent estimate puts the needed temperature at (1 @.@ 90 ± 0 @.@ 02) × 1012 kelvin . While a state of entirely free quarks and gluons has never been achieved (despite numerous attempts by CERN in the 1980s and 1990s) , recent experiments at the Relativistic Heavy Ion Collider have yielded evidence for liquid @-@ like quark matter exhibiting " nearly perfect " fluid motion .

The quark ? gluon plasma would be characterized by a great increase in the number of heavier quark pairs in relation to the number of up and down quark pairs . It is believed that in the period prior to 10 ? 6 seconds after the Big Bang (the quark epoch) , the universe was filled with quark ?

gluon plasma , as the temperature was too high for hadrons to be stable .

Given sufficiently high baryon densities and relatively low temperatures ? possibly comparable to those found in neutron stars ? quark matter is expected to degenerate into a Fermi liquid of weakly interacting quarks . This liquid would be characterized by a condensation of colored quark Cooper pairs , thereby breaking the local SU (3) c symmetry . Because quark Cooper pairs harbor color charge , such a phase of quark matter would be color superconductive ; that is , color charge would be able to pass through it with no resistance .