# Kobayashi and Maskawa win the Nobel Prize for work on CP violation

In 1957, experiments in beta decay of nuclei and in decays of pions and muons showed that parity (*P*) was not conserved and hence nature was not left–right symmetric[1]. In addition, the charge conjugation symmetry (*C*) was also broken. However, theorists were quick to seek solace in the possibility that *CP* (the product) or a generalized particle–antiparticle symmetry was still conserved[2]. But this comfort was to prove short-lived; as in 1964, a team of physicists led by Fitch and Cronin at Princeton University found small effects in decays of *K* mesons, which meant that *CP* invariance was broken as well[3]. Later (in 1966), this effect intrigued Andre Sakharov[4] and led him to propose a possible explanation for the observed matter–antimatter asymmetry in the universe at large. He wrote down conditions required for such an explanation, and breaking of *CP* invariance was a necessary one.

This broken symmetry remained mysterious for quite some time, despite many efforts by theorists for possible explanations, and furthermore no new experimental breakthroughs occurred. In 1972, Kobayashi and Maskawa working at the Yukawa Institute, Kyoto, wrote a paper on *CP* violation in renormalizable theory of weak interactions[5]. They showed that in the theory of Glashow, Salam and Weinberg (now called the 'standard model')[6], with two families of quarks and leptons, there is no complex phase which can lead to *CP* violation. They catalogued the ways in which the theory can be modified so that such a phase can be accommodated. They listed the possibilities: (i) to introduce right-handed currents coupling to the gauge bosons, (ii) to introduce extra scalar bosons, and (iii) to increase the number of families from two to three, and hence have six quarks. In 1975, Pakvasa and Sugawara, working at the University of Hawaii[7], pointed out that the six-quark option could indeed account for the observed *CP* violation the *K* decays and be consistent with all other phenomena, and could be further tested in future experiments. They were the first ones to point out the existence of the Kobayashi–Maskawa proposal and its simplicity, viability and promise, and in so doing contributed to spreading the word. Later Maiani[8] at University of Rome, reached similar conclusions and a few months later John Ellis, Gaillard and Nanopoulos[9] at CERN in Geneva gave a detailed analysis of the six-quark option.

At the time of the proposal by Kobayashi and Maskawa, only three quarks (*u*, *d* and *s*) were known, although there was some preliminary evidence for the fourth quark (*c*) from the cosmic ray group of Niu at Nagoya[10]. In 1974, teams led by Ting at Brookhaven and Richter at SLAC discovered the $J/\psi$ particle[11], which turned out to be a bound state of *c* and $\overline{c}$ quarks (antiparticles are denoted by a bar on the top). Soon the 'naked' *c* quark in *D* mesons was also detected by a LBL–SLAC team led by Goldhaber[12].

In 1977, Lederman and collaborators at Fermilab[13] discovered the bound state of the fifth quark (*b*) and its antiquark ('upsilon'). Later at CESR (Cornell) and at DESY, mesons containing single *b* quarks were also detected[14]. In 1983, the MAC and MarkII collaborations at SLAC found that mesons containing *b* quarks have rather 'long' lifetimes[15], as long as $10^{-12}$.

Incidentally, the third family of leptons was also confirmed with the discovery of the $\tau$ lepton by Perl and co-workers[16], at SLAC in 1975, and the observation of the $\tau$-neutrino at Fermilab by the DONUT collaboration in 2000 (ref. 17).

Bigi and Sanda (SLAC and Rockefeller University) showed in 1983 that if the *B* lifetimes are long and mixing in the $B^0 - \overline{B}^0$ system is large, then *CP* violating asymmetries (expected in the K–M picture) in *B* decay can be large and observable, and pointed out ways to measure them[18].

Large $B^0 - \overline{B}^0$ mixing was discovered by the ARGUS collaboration at DESY, Hamburg in 1987 (ref. 19). In 1995, the sixth and final quark was detected at Fermilab by both CDF and D0 collaborations[20]. All six quarks needed to implement the K–M proposal were now at hand.

During the mid-90s, both at SLAC and KEK, two B-factories, that is, electron–positron colliders which produced a very large number of *B* mesons were built along with two dedicated detectors: Belle at KEK and BaBaR at SLAC. Several Indian institutions have been associated with the Belle collaboration: Utkal University (Bhubaneswar), Punjab University (Chandigarh), Tata Institute of Fundamental Research (Mumbai) and Institute of Mathematical Sciences (Chennai). In 2001, both Belle and BaBaR detected[21] large *CP*-violating asymmetry in the decays of $B \rightarrow J/\psi + K$, exactly as expected in the K–M model. All predictions of the K–M model: three families, six quarks and the large asymmetries in *B* decays were now confirmed. In 2008, they were awarded the Nobel Prize in Physics[22].

Note: The following people received Nobel Prizes for the work referred to above: Fitch and Cronin, 1980; Glashow, Salam and Weinberg, 1979; Ting and Richter, 1976; Perl, 1995. Sakharov received the Nobel Peace Prize in 1975, and Lederman the Physics Prize in 1988 for work on neutrinos. Kobayashi and Maskawa shared the 2008 physics Nobel Prize with Nambu.


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# Calamity-resistant biosafety laboratory

The University of Texas Medical Branch (UTMB) facility in Galveston – home to two national biocontainment laboratories – has been in the news for surviving the deadly Ike hurricane. The 13 September calamity caused damages equalling US$ 700 million to the University of Texas facilities[1]. The US$ 180 million worth medical laboratory of Galveston is facilitated to withstand winds as strong as those of tornadoes. It contains a Biosafety Level 4 (BSL-4) laboratory to house deadly pathogens such as *Anthrax bacilli* and *Ebola* viruses, for which there are no effective drugs or vaccines[2].

The biosafety experts at the UTMB claim that their laboratory is sturdy enough to withstand almost any natural disaster, stressing that though Ike washed away whole sections of Galveston, it left the university's biodefence research facilities completely intact[3].

The officials at the US Department of Health and Human Services have designed the new laboratory to resist 140 miles/h hurricane winds and also withstand earthquakes according to the requirement of the National Earthquake Hazards Reduction Program. In addition to standby generators to provide power in case of a power failure, the Galveston National Laboratory boasts of uninterruptible power supply module or a fuel-cell power supply to power the BSL-4 biosafety cabinets, BSL-3 enhanced biosafety cabinets, and critical building control panels. The building is also said to be equipped with an environmental monitoring system to assess room pressure differentials, smoke detection, automatic watering system pressure and flow, as well as high efficiency particulate air filters. The proposed laboratory will have fire protection systems that meet or exceed requirements specified by the National Fire Protection Association and all applicable local, State, Federal, and UTMB requirements[4].

However, opponents of the new laboratory, set to research some of the world's most dangerous diseases, opine that housing it in a major hurricane zone is akin to inviting accidents. Biological agents stored in the laboratory, which is less than a mile from the sea wall, could leak out after damaging winds or flooding, or could be looted by rioters in post-disaster mayhem. Infectious exotic agents such as Congo–Crimean hemorrhagic fever viruses[5] with potential for aerosol transmission pose a high risk of exposure and infection to laboratory personnel, the community and the environment. Facilities such as this are generally housed in a separate building or isolated zone with complex, specialized ventilation requirements and waste management systems to prevent release of viable agents to the environment.

The threats to constructing the Galveston National Laboratory noted in the Record of Decision include vulnerability to severe storms, including hurricanes; location within a 100-year floodplain, and location within the Gulf Coast Normal Faults Region (earthquakes). Other than vulnerability to hurricanes, floods and earthquakes, the idea of locating a BSL-4 laboratory on a barrier island in the Gulf of Mexico made perfect sense. Americans fear that laboratories of such stature situated near the coast may pose a risk to their health, should there be any environmental slip-ups[1].

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# TWAS, illycaffè announce Trieste Science Prize winners 2008

A press release from Trieste, Italy, dated 29 September 2008 announced the Trieste Science Prize Winners 2008. The prize, is administered by TWAS, the academy of sciences for the developing world, and illycaffè in collaboration with the city of Trieste and Fondazione Internazionale per il Progresso e la Libertà delle Scienze. The prize provides international recognition to outstanding scientists living and working in the developing world. Winners share a US$ 100,000 cash award.

The winners in 2008 are Beatriz Barbuy, an eminent Brazilian astrophysicist,