BABAR searches for New Physics in B decays to invisible final states

The Standard Model (SM) of particle physics has been proven by numerous experiments over many years to correctly describe the interactions mediated by the strong and electroweak forces. Despite this great success, we know that it cannot be the ultimate theory of particle physics, which motivates searches for physics beyond the SM. Processes that are predicted by the SM to be very rare are well suited for this purpose, since their observation would be an unambiguous signal for new phenomena.

The *BABAR* collaboration has recently published[i] the results of a search for invisible decays of neutral *B* mesons, where unobservable particles are created in the final state, either exclusively or accompanied by a single photon. The invisible decay products are neutral particles that interact so weakly with ordinary matter that they leave no signal in the detector.

The relevant SM decays are $B^0 \to \nu\bar{\nu}$ and $B^0 \to \nu\bar{\nu}\gamma$, which are predicted to have unobservably low probabilities. The decay $B^0 \to \nu\bar{\nu}$ is suppressed by a factor of order $\left(m_\nu / m_{B^0}\right)^2$. This ratio cannot be calculated because neutrino masses have never been measured, but the limit on the decay rate is far below the experimental sensitivity. The $B^0 \to \nu\bar{\nu}\gamma$ branching fraction is predicted by the SM to be of order 10^{-9}, which is again too small to be observed in current experiments. However, several models of new physics allow for invisible decays of B^0 mesons with significantly higher branching fractions, up to 10^{-6}. In these scenarios, the invisible decay products include new exotic particles, such as neutralinos from Supersymmetric theories.

The search for these decays can be performed only at electron-positron *B* Factories in events consisting solely of a $\Upsilon(4S)$ decaying to a $B^0\overline{B}^0$ pair. So far, such a study has only been performed by *BABAR*, where a search for these decays was conducted by reconstructing one of the *B* mesons in the semileptonic decay channel $B^0 \to D^{(*)-}\ell^+\nu$, and allowing no other particles in the event other than a single energetic photon. Background was suppressed by making use of a neural network based on several discriminating variables, and by looking at the residual energy measured by the electromagnetic calorimeter after subtraction of the energies of the reconstructed particles.

No significant signal was observed in either channel and 90% C.L. upper limits of 2.4×10^{-5} and 1.7×10^{-5} were set on the branching fractions of $B^0 \to invisible$ and $B^0 \to invisible + \gamma$, respectively. This is a significant improvement over the previous analysis, which used a data sample about five times smaller, and places stringent new limits of physics beyond the SM. The precision of the measurement is limited by the data sample size. The next generation of planned Super *B* Factories, SuperKEKB in Japan and Super*B* in Italy, with a hundred times larger data set, could effectively probe several new physics models, and potentially reach a discovery in these channels.

[i] Phys.Rev.D86, 051105(R) (2012)