RESEARCH INTERESTS

Associate Professor Ismail Ruhi UMAN

Since 1996 my research activities in particle physics is mainly about **light quark spectroscopy**, that is the observation of resonances made by the lighter u, d and s-type quarks only, through **data analysis** of **High Energy Physics** (HEP) experiments up to 2.5 GeV. For this purpose I joined several international collaborations, like Crystal Barrel (CERN), E835 experiment at Fermilab, COMPASS experiment (CERN) and recently BESIII at the Institute of High Energy Physics (IHEP) in Beijing, China.

The particle physics standard model predicts that the nuclear matter is formed by quarks and leptons and they mediate through gluons, photons and W and Z bosons which are the carrier of the strong, electromagnetic and weak force, respectively. According to the theory of Quantum Chromo-Dynamics (QCD), hadrons are grouped in two families, mesons (which are formed by quark and anti-quarks pairs), like pions and kaons, and baryons (three quarks), like protons and neutrons. However, unlike photons, which do not interact with other photons, according to the theory of QCD, gluons can also interact among themselves so nuclear matter may have also a gluonic degree of freedom and states like **glueballs** (particles with two or three gluons bound together) and **hybrids** (particles with quarks and gluons) may exist.

With the Crystal Barrel experiment I investigated **proton-antiproton annihilations** at low energies where glueballs may be produced, developed a **Partial Wave Analysis** (PWA) program and performed a **Dalitz Plot** analysis, which I use to determine the properties, like spin, mass and width, of the intermediate resonances produced in the reactions. Doing PWA I observed $f_0(1710)$, which is considered a glueball candidate in proton-antiproton annihilation for the first time. With the E835 experiment I adapted the same PWA program to confirm this state and I observed both glueball candidates, $f_0(1500)$ and $f_0(1710)$, at a much higher incoming antiproton energy and with higher statistics. In the COMPASS experiment the production mechanism of resonances is different: incoming high energetic pions and kaons at 190 GeV collide with a fixed proton target and the kinematics of this reaction is more complicate because two main processes, **diffractive scattering** and **central production** occur at the same time. With the former and dominant reaction we were able to discover the second type of non-ordinary particles, the exotic $\pi(1400)$ and $\pi(1600)$. These states are considered today the best candidate of hybrid mesons because they have unconventional quantum numbers, which are not allowed to ordinary $q\bar{q}$-mesons. In the second type of reaction one can observe resonances centrally produced where we do expect glueballs to be formed, however the rapidity gap between the diffractively and centrally produced resonances is not sufficient to unambiguously isolate the production of glueballs from the dominant diffractive scattered resonances and to determine their spin with standard PWA methods. My research interest includes therefore also the development of new PWA techniques to study these two type of reactions at the same time.

Part of my responsibilities in HEP experiments was about coordinating the **Monte Carlo (MC) simulation** group and the **calibration of the drift chambers and electromagnetic calorimeters**, and I plan to verify that the simulation is realistic and that the calibration parameters are correctly implemented in BESIII, too.

The BESIII experiment, which collected the biggest world sample of **positron-electron annihilations**, has a clean production mechanism and a much simpler kinematics at higher available energy in the center of mass system up to 4.6 GeV and with a luminosity of $10^{33} cm^{-2} s^{-1}$. Therefore with BESIII we are able to observe with higher precision not only light quark states but also to investigate heavier $c\bar{c}$-states, i.e. **charmonium states** made by c-type quarks like the J/ψ meson. As in the light quark sector we observed many predicted and unpredicted states, like $Z_c(3900)$. This state is believed to be formed by four quarks (**tetra-quark)** instead of the conventional charm and anti-charm quark, and the determination of multi-quark states is one of the important recent challenges in particle physics. In line with BESIII many other tetra-quark candidates were observed by the LHCb experiment at CERN and by the BELLE experiment in Japan. Since these discoveries my main future goal is to continue to determine and classify ordinary mesons and isolate the possible unconventional and exotic mesons not predicted by the standard model, not only in the light quark but also in the charm sector.

Since I'm back in Turkey and now in North Cyprus I'm sharing my expertise in HEP with other particle physicists in the region. For this purpose I'm joining BESIII together with a cluster of Turkish Universities: Bilgi University, Ankara University, Uludağ University.

The collaboration to these kind of experiments requires not only the analysis of the data but also a worldwide common huge effort in **detector construction**, calibration of the individual components, **writing the software** and **running** the experiment, together with more than 400 scientists and 50 institutions. Also for the analysis of the huge amount of data, the computer resources of the participating institutes are shared as well. Since I joined the Near East University together with the IT division, we were able to deploy the High Performance IBM Computer at NEU which is now running continuously the BESIII Offline Software via a **distributed computer system**. Now I'm interested also to share supercomputers in HEP through the worldwide **grid system**.