Preface

General relativity (GR) is the standard theory of gravity that has an elegant and internally consistent theoretical structure and its observational predictions are confirmed by a variety of experiments. However, GR has been tested mainly in the weak field regime and remains effectively untested in the strong/moderately strong field region. Moreover, to explain the recent observations on large astronomical/cosmological scales an exotic energy component having nearly homogeneous energy density with negative pressure, the so called dark energy and also a non-luminous unseen matter, the so called dark matter have to be invoked. In fact several independent analysis of cosmological data now firmly suggest that dark energy, dark matter and luminous matter constitute about 72%, 23% and 5% of the total energy budget of the universe. Thus exploring the observational effects of GR including the effects of dark energy and dark matter, both theoretically as well as experimentally, is of prime importance in the present day gravitational research.

In this thesis, we report the results of our theoretical investigation that was targeted to search for effects of GR/dark energy/dark matter in local gravitational phenomena with observational prospects. We particularly study gravitational time delay of particles with non-zero mass and explore how the phenomenon can be exploit to probe dark matter/energy. We also study effects of spin, naked singularity spacetime geometry, cosmological constant on stationary accretion flow. In this regard, we employ pseudo-Newtonian potential technique. The pseudo-Newtonian potentials for the relevant spacetime geometries those can reproduce almost all of the corresponding GR features with good accuracy are derived first; subsequently they are employed to examine the effects of GR on accretion. Besides, we also analyze the X-ray astronomical data obtained with the Rossi X-ray Timing Explorer (RXTE) and XMM Newton to extract information regarding nature of compact objects (black hole etc) and emission processes which may give some confirmation of the gravitational theories.