Chapter 6

BRIEF SUMMARY OF THE THESIS

Experimentally, Delbrück scattering has been investigated covering a wide range of gamma-ray energies (1-1000 MeV) in the last eight decades. Both, the real as well as the imaginary parts of Delbrück amplitudes have been experimentally detected. On the theoretical side, even though a reasonable understanding of the Delbrück scattering has been achieved so far, there is still no general solution of Delbrück scattering problem for arbitrary photon-energies and scattering-angles. All the theories developed so far have their own ranges of validity. Of these, the theories which are well established include the results for forward scattering [30], and the high-energy small-angle ($\omega >> m, \Delta << \omega$) regime [32, 33, 41, 42]. The calculations of Delbrück amplitude based on the lowest-order Born approximation [49] are found to be valid at lower energies ($\omega \leq 1.33$ MeV) and all scattering angles. For larger photon energies ($\omega > 1.33$ MeV), Coulomb correction terms are to be added to the Born approximation amplitudes. Thus a general theoretical prediction of Coulomb correction terms are needed until a more general treatment of Delbrück scattering problem valid in this energy regime becomes available. The conventional perception is that the amplitudes of Delbrück scattering calculated to all orders in the charge number Z of the target nucleus should exhibit a scaling behavior at high energies. To examine this hypothesis the available experimental data of differential cross sections of elastic scattering in the energy range between 140 MeV to 7.11 GeV are analyzed. It is found that the experimental data do not show scaling characteristics. Such a finding though apparently against the standard notion, is not unexpected since at high energies Delbrück scattering is in very forward direction and the theoretical arguments demand that to observe scaling, not only the energy itself but the product of scattering angles and energy also should be very large.

As the contribution of nuclear resonance scattering to the elastic scattering in the energy range between 7 and 20 MeV is significant, its accurate calculation is possible provided the GDR parameters are precisely determined. A fine tuning of GDR parameters and Coulomb correction estimates can be achieved by means of future experiments in energy range of 5-40 MeV [110]. In the energy range between 20 and 100 MeV, the present experimental results suffer from large uncertainties and thus the predictions of the large-angle high-energy approximation [45, 46, 54] could not be verified at the desired level. Experiments with better accuracies are needed at this energy range for proper testing of the theoretical predictions.

Accurate measurements of gamma-ray attenuation coefficients are necessary not only in radiological applications but also in verifying the theoretical predictions of various photon-atom processes. The overall agreement between the predictions and the measurements of attenuation coefficients are good [117]. However, there exists some discrepancy between the XCOM [119-121] and FFAST [122] predictions for high Z elements. For Z lying between 60 and 82 the discrepancies being 15-50 % near absorption edges and 2-5 % throughout the high energy range [123]. The measured values of attenuation coefficients presented in this thesis are in agreement with the theoretical values tabulated in XCOM [119]. Though the difference between the theory and the experiment is within 1.5 %, it is worthwhile to note that most of the measured values of the total cross sections are consistently smaller than the XCOM predictions.

Among the other developments related to Delbrück scattering, the possibility of photon emission in collisions of ultra-relativistic heavy nuclei ($Z_1Z_2 \rightarrow Z_1Z_2\gamma$) via the virtual Delbrück scattering sub-process [16, 17], the modification of Delbrück scattering by the application of intense laser field [12], the possibility of observing Delbrück-scattered γ-rays from objects like a gamma ray burst or pulsar is [chapter 5 of this thesis] etc. are interesting findings from the point of view of future observations.