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Project Description: Application of Gauge Theories to Enhance Numerical Solutions to Mixed Potential Integral Equations
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The purpose of this research is to incorporate new advances in gauge techniques currently being researched in mathematical physics into numerical electromagnetic scattering routines with an emphasis on improving computation speeds and the versatility of current methods. During this past year we have developed a new scheme for solving two dimensional electromagnetic scattering problems in which the scatterer can be inhomogeneous. The Fourier transform path integral method (FTPI) is based on the Feynman path integral which is a Green's function for inhomogeneous regions.

Although originally proposed in the late 40's path integral applications have been restricted to a limited variety of problems in quantum physics. This has been the case primarily because it is not a closed form expression but rather a sequence of nested integrals with infinite limits, which can only be evaluated by making stringent approximations that in turn limit the geometries to which it is applicable. Our contribution has been that we were able to transform the original path integral into a form where the nested sequence because successive Fourier and inverse Fourier transforms. We can now take advantage of the well known fast Fourier transform (FFT) routines currently available to evaluate the path integral.

Over the past year we have worked on solving electromagnetic field problems in one and two dimensions and on the dual problem of determining the scattering coefficients for a particle in the presence of a potential barrior. Because specialists in quantum mechanics have worked with the path integral in the past with only limited success we have also developed a FTPI method for computing energy levels in one, two and three dimensional quantum wells with general (inhomogeneous) potential levels. Also the several potential barrior analytical solutions that are widely published in the quantum field literature have given us the necessary data with which to compare our numerical calculations and thereby verify the FTPI method.

Our main efforts have been concentrated on the several numerical problems that have arisen in the implementation of the FTPI method. To date our asscessment of the FTPI method is that it offers remarkable versatility in that it can compute scattered fields for a large variety of two dimensional geometries. It automatically satisfies Dirichlet boundary conditions and the radiation condition. Inhomogeneous bodies are handled as easily as those that are homogeneous and without modification of the source program. The main tradeoff is that computation times with the FTPI method are large. However the speed of computation does not depend upon the complexity of the scattering body to the extent it does with other numerical methods. A typical computation time on a CRAY Y-MP2/116 for a two dimensional scatterer is 300 CPU. In some cases this is several hundred times faster that the same calculation on the same computer using the Monte Carlo scheme we reported on last year (and have since improved upon).

Our immediate goals are to find a way to extend the FTPI method so that it can be applied to general three dimensional situations and to continue to improve the accuracy and speed of the FTPI routines we now have.