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The USRA activities are included in a separate report which is submitted as a sub-contract report in the appendix.

GRAVITATIONAL PHYSICS RESEARCH

The ISPAE members here are UAH employees only. Gravitational physics research at ISPAE is connected with NASA's Relativity Mission (Gravity Probe B - GP-B) which will perform a test of Einstein's General Relativity Theory. GP-B will measure the geodetic and motional effect predicted by General Relativity Theory with extremely stable and sensitive gyroscopes in an earth orbiting satellite. Both effects cause a very small precession of the gyroscope spin axis. The goal of the GP-B experiment is the measurement of the gyroscope precession with very high precision. GP-B is being developed by a team at Stanford University and is scheduled for launch in the year 2001. The related UAH research is a collaboration with Stanford University and MSFC. This research is focussed primarily on the error analysis and data reduction methods of the experiment but includes other topics concerned with experiment systems and their performance affecting the science measurements. The hydrogen maser is the most accurate and stable clock available. It will be used in future gravitational physics missions to measure relativistic effects such as the second order Doppler effect. The HMC experiment, currently

under development at the Smithsonian Astrophysical Observatory (SAO), will test the performance and capability of the hydrogen maser clock for gravitational physics measurements. UAH in collaboration with the SAO science team will study methods to evaluate the behavior and performance of the HMC. The GP-B data analysis developed by the Stanford group involves complicated mathematical operations. This situation led to the idea to investigate alternate and possibly simpler mathematical procedures to extract the GP-B measurements form the data stream. Comparison of different methods would increase the confidence in the selected scheme.

The UAH gravitational physics team visited Stanford GP-B group in May 1996 to review the experiment simulation work done at Stanford University and discuss a joint approach for future simulation studies. The Stanford GP-B computer program was obtained and modified for simplified simulation studies with a PC. The results of this work was documented in a report. Work began on an advanced and expanded computer simulation of the experiment including science measurements and data reduction. This computer program used with a Sun Work Station to simulate and analyze the experiment during a one year mission.

An analytical study of error torques on the GP-B science gyroscope was completed and a report was prepared. A computer simulation study to investigate the errors caused by noise in the experiment readout (SQUID) system was started and will be completed early in 1997. A review of all experiment errors was carried out to identify the most critical error sources and to define further analytical investigations needed to assess the science measurement accuracy of the experiment. This effort was carried out in collaboration with NASA scientists.

A continuing study, started by P. Eby, involves an alternate method to estimate the experiment parameters from the received data during the mission. The Stanford team approach uses a two step process with a Kalman filter. The UAH study investigated a least squares method for the data reduction. There was some disagreement in the results obtained with the two methods. The more recent work included the addition of a calibration signal to the UAH least squares simulation of the experiment data reduction. This did not reduce the errors due to random walk time variations in the SQUID scale factor. As a next step a Fortran program was developed to implement Stanford's Kalman filter equations independently. The results of this new simulation confirm Stanford's result that the Kalman filter is necessary to handle the expected level of random walk type time variation in the scale factor. It also confirms our previous result that the least squares method is not adequate to reduce the errors of this type to the required level. In the continuing analysis we have tried to answer the question of how one chooses the parameter in the filter which specifies the expected (but unknown) level of random walk in the scale factor in the actual data. We also discuss how the choice of this parameter affects the error in the frame dragging measurement. The results of this study are being documented and the related report will be finished in early 2000. Details of the above study were discussed with A Silvergleit from the Stanford analysis group during his visit at MSFC in March 1999. The work emphasis shifted from error analysis and experiment simulations to reviewing the development of the science data reduction and analysis in progress at Stanford. Part of this effort included reviewing the algorithms to be used in the data reduction scheme. Tests had shown that the gyroscope spin speed would be lower than predicted from previous test. Using the existing error analysis model and experiment simulation the dependence of the experiment accuracy on gyro spin speed was determined and it was shown that the experiment accuracy goal could be achieved with the lower

spin speed. Another subject was the definition of criteria for the scientific success of the GP-B mission i.e. the final accuracy in the measurement of the gyroscope precession for changing conditions during flight. Using different mission durations (amount of data collected in orbit), the relationship between measurement duration and final experiment accuracy was established with the error analysis model. R. Decher has visited Stanford University many times the period of performance to participate in the Science Advisory Committee meetings and monthly reviews of GP-B. In addition, several topics related to the experiment error analysis and data reduction were discussed e with the Stanford team during these visits. This included alternate mathematical approaches developed by the UAH group. An interim report on the application of the least squares analysis (by P. Eby) was published in January 1999. Several brief presentations on various subjects were given to the GP-B Project Office.

SOLAR PHYSICS

The solar physics group (consisting only of UAH employees). The areas of emphasis are: (a) develop theoretical models of the transient release of magnetic energy in the solar atmosphere, e.g., in solar flares, eruptive prominences, coronal mass ejections, etc.; (b) investigate the role of the Sun's magnetic field in the structuring of solar corona by the development of three-dimensional numerical models that describe the field configuration at various heights in the solar atmosphere by extrapolating the field at the photospheric level; (c) develop numerical models to investigate the physical parameters obtained by the ULYSSES mission; (d) develop numerical and theoretical models to investigate solar activity effects on the solar wind characteristics for the establishment of the solar-interplanetary transmission line; (e) develop new instruments to measure solar magnetic fields and other features in the photosphere, chromosphere transition region and corona.During the period, we focused our investigation on the fundamental physical processes in solar atmosphere which directly effect our Planet Earth. The overall goal is to establish the physical process for the Sun-Earth connections.

Dr. David Falconer, Research Associate, has been primarily investigating coronal heating using a combination of Yohkoh/SXT, SOHO/EIT, MSFC vector magnetograms, Kitt Peak magnetograms, and SOHO/MDI. This has involved analysis of coronal heating in active regions, with investigation of the role of global nonpotentiality. He has also investigated quiet sun coronal heating. Also, and has done a pilot study on the two quantitative predictors of which active regions might produce flare-associated coronal mass ejections. The first having to do with quiet sun heating, and the second with non-Maxwellian effects on line-ratio temperature diagnostics.

Dr. Manfred Cuntz has been involved in a variety of projects relevant to solar and stellar astrophysics. His main projects were the following: (1) study of two-component chromospheric heating in stars of different magnetic activity taking K2V stars as examples. These computations made use of a magnetohydrodynamic computer code package, which had been developed by Drs. P. Ulmschneider, W. Rammacher, Z.E. Musielak, and M. Cuntz. The code package allows the treatment of the generation, propagation, and dissipation of magnetic and acoustic wave modes and the formation of specific spectral emission lines. The performed simulations allowed the explanation of the empirically deduced relationship between the Ca~II and Mg~II emission and