Curriculum Vitae

Name	**Anshu Gupta**
Date of Birth	**14. 06. 1970** *(Fourteenth June Nineteen Seventy)*
Sex	**Female**
Nationality	**Indian**
Present Address	*The Institute of Mathematical Sciences,* *C.I.T. Campus,* *Taramani,* *Chennai 600 113,* *INDIA* Fax: +91 (044) 254 1586 Phone: +91 (044) 254 1049 E-mail: anshu@imsc.ernet.in anshu_rrj@yahoo.com

Educational Qualifications

- Ph. D. : Physical Research Laboratory (PRL), Ahmedabad 1997.
- M. Sc. : Department of Mathematics, University of Rajasthan, Jaipur (1991).
- B. Sc. : Maharani's College, Univ. of Raj, Jaipur (1989).

Thesis Title

Studies of fluid distribution with magnetic fields and analysis of ultra compact objects with Centrifugal Force Reversal

Thesis Supervisor : Prof. A. R. Prasanna,
Physical Research Laboratory, Ahmedabad
(E-mail: prasanna@prl.ernet.in).

Professional Experience

- Post-Doctoral Fellow, The Institute of Mathematical Sciences, Chennai (April 2001 onwards).
- Visiting Scientist, The Institute of Mathematical Sciences, Chennai (Jan. 2001-April 2001).
- Post-Doctoral Fellow, Raman Research Institute, Bangalore (Dec. 1998-2000).
- Post-Doctoral Fellow, PRL, Ahmedabad (March 1997-Nov. 1998).

Recent Awards/Prizes

- Post-Doc award of ICSC-World Laboratory (Lausanne, Switzerland) fellowship in mathematical physics, in memory of Prof. S. Chandrasekhar, Jan. 98.

Publications/ Pre-prints

- Axisymmetric Modes of Rotating Relativistic Stars in the Cowling Approximation,
  J. A. Font, H. Dimmelmeier, *Anshu Gupta* and Nikolaos Stergioulas
  In press *MNRAS* and astro-ph/0012477.

- Padé approximants for truncated post-Newtonian neutron star models,
  Anshu Gupta, A. Gopakumar, B. R. Iyer and Sai Iyer
  Phys. Rev. D 2000 **62** 044038.

- Čerenkov radiation by charged particles in an external gravitational field and detection of cosmic strings,
  Anshu Gupta, Subhendra Mohanty and Manoj K. Samal
  Class. and Quant. Grav. 1999 **16** 291.

- Rotating compact objects with magnetic fields,
  Anshu Gupta, Amruta Mishra, Hiranmaya Mishra and A. R. Prasanna
  Class. and Quant. Grav. 1998 **15** 3131.

- Structure of External Electromagnetic Field around a Slowly Rotating Compact Object and Charged Particle Trajectories Therein,
  A. R. Prasanna and *Anshu Gupta*
  Il Nuovo Cimento B 1997 **112** 1089.

- Studies of behavior of centrifugal force and ellipticity for various equations of state in optical reference geometry,
  Anshu Gupta, Sai Iyer and A. R. Prasanna
  Class. and Quant. Grav. 1997 **14** L143.

- Centrifugal force and ellipticity behavior of a slowly rotating ultra compact object,
  Anshu Gupta, Sai Iyer and A. R. Prasanna
  Class. and Quant. Grav. 1996 **13** 2675.

Research Specialization

- General Theory of Relativity
- Relativistic Astrophysics

Teaching/Tutorials

- Summer project on "Truncated TOV models: a comparison of Taylor, Padé and Shanks approximations" May 15-June 27, 2000.
- GR tutorials during RRI summer student's program June 1-June 7, 1999

Computer Experience

- Programming Languages: Fortran 77, C and working knowledge of c++, F90 and Perl.
- Packages: IMSL (numerical calculations). Mathematica and to some extent Maple and Matlab for GR and other calculations along with their graphic tools.
- Additional Plotting packages: sm, xmgr, idl etc.
- Architectures: IBM RS/6000, Sun UltraSparc (single and multiple CPU), SGI (multiple CPU), Dec-alpha, Linux cluster.
- Linking two Linux machines using MPI (MPICH), Compiling and executing parallel code (Cactus) on this (proto-type!) 2-processor distributed memory system.

  Cactus is a modular, parallel, collaborative 3-dimensional numerical relativity code. It could be also used as a computational toolkit to solve partial differential equations through finite differencing schemes. It is portable on SGI Origin 2000, Cray T3E, Dec Alpha, Linux (Linux Cluster).

Recently attended scientific meetings

- High performance computing and Cactus Toolkit workshop, Sept. 27-Oct.1, 1999, NCSA, Champaign-Urbana.
- A workshop on Parallel computation and cluster supercomputer (CSC) July 17-21, 1999, IMSc, Madras.
- XIX Astronomical Society Meeting at RRI, Bangalore, Feb.1-4, 1999.
- GR15 at IUCAA, Pune, Dec. 16-21, 1997.
- Golden Jubilee meeting on 'Gravitational Radiation and Quantum Gravity' at RRI, Bangalore, Dec. 11-14, 1997.
- Discussion Meeting on Physics of Black Holes at CTS, IISC, Bangalore, Dec. 8-10, 1997.
- Astronomical Society Meeting (ASI) at PRL, Ahmedabad, Nov. 28-Dec. 1, 1997.
- Golden Jubilee Symposium on 'Gravitation and Particle Physics' at PRL, Ahmedabad (India), Dec. 10-14, 1996.
- International Conference on Gravitation and Cosmology (ICGC) held at IUCAA, Pune (India), Dec. 14-19, 1995.

Talks given/Visits

- A short visit for scientific discussions to Max Planck Institute of Astrophysik, Garching, Germany, Oct.27-29, 1999.
- A collaborative visit to numerical relativity group, Albert Einstein Institute, Golm, Germany, Oct 4-Nov. 15, 1999.
- Short talk on PADÉ APPROXIMANTS FOR A TOV STAR, during Cactus workshop, Oct. 1, 1999 at NCSA, Champaign.
- Talk on REPORTING ON THE MEETING ON 'CLUSTER SUPER COMPUTER' AT INST. OF MATH. SCIENCES, CHENNAI, Sep. 1999 at RRI.
- Collaborative visit under TPSC program to PRL, Ahmedabad, March 26-April 25, 1999.
- RRI, Bangalore visit, Feb.24-27, 1998 and Seminar on BEHAVIOUR OF CENTRIFUGAL FORCE AND ELLIPTICITY IN GENERAL RELATIVISTIC FRAMEWORK.
- Visit to TIFR, Bombay, Feb.5-10, 1998, under Theoretical Physics Seminar Circuit (TPSC).
- Talk on CENTRIFUGAL FORCE AND ELLIPTICITY BEHAVIOUR OF A SLOWLY ROTATING ULTRA COMPACT OBJECT in GR15, Dec.'97, at IUCAA, Pune.
- Seminar on BEHAVIOUR OF CENTRIFUGAL FORCE AND ELLIPTICITY IN GENERAL RELATIVISTIC FRAMEWORK, Oct. 1997 at PRL, Ahmedabad.
- One month visit in July 96 at IUCAA, Pune.
- Talk on ELECTROMAGNETIC FIELD STRUCTURE AROUND A SLOWLY ROTATING BODY during ICGC 95 (in workshop on Classical General Relativity) at IUCAA, Pune.
- Poster presentation on BEHAVIOUR OF CENTRIFUGAL FORCE AND ELLIPTICITY during ICGC 95 at IUCAA, Pune.

References

- Prof. B. R. Iyer,
  Raman Research Institute, Bangalore, India.
  E-mail: bri@rri.ernet.in
- Dr. Nikolaos Stergioulas,
  Department of Physics,
  Aristotle University of Thessaloniki,
  Thessaloniki, Greece.
  E-mail: niksterg@astro.auth.gr
- Dr. Hiranmaya Mishra,
  Physical Research Laboratory, Ahmedabad, India.
  E-mail: hm@prl.ernet.in

Current and Recently Completed Research projects:

- **Hydrodynamical evolution of rotating relativistic stars:**

  Currently I am involved in numerical evolution of a rapidly rotating general relativistic star. We are studying 1. Quasi-radial modes of a rapidly rotating neutron star and 2. pulsation modes of a differentially rotating, hot proto-neutron star.

  These studies incorporate non-linear effects which are very important in finding out the maximum amplitude of an unstable r-mode limited by nonlinear saturation, transfer of energy to other stable or unstable modes via nonlinear coupling, possible transition of a uniformly rotating star to differentially rotating star due to r-mode evolution etc. To carry out these studies, we are using an axisymmetric, non-linear, general relativistic hydrodynamical code, under Cowling approximation (i.e., assuming spacetime static). This code has been well tested and uses High Resolution Shock Capturing (HRSC) finite differencing schemes to describe the general relativistic hydrodynamic equations written in a first order flux conservative form.

  The matter distribution inside the star is described by a polytropic equation of state (EOS) and the initial models are exact numerical solutions of rapidly rotating relativistic stars, having uniform velocity between zero and the mass shedding limit. These initial models are appropriately perturbed using even and odd parity eigenfunctions and are evolved numerically. Through Fourier transforms of the time evolution of fluid's density and velocity functions, we have computed the axisymmetric modes ($l = 0, 1, 2$ and 3). The frequencies for these modes are affected significantly due to rotation when the rotation rate exceeds about 50% of the maximum allowed. For large rotation rates, apparent mode crossings are also noticed, consistent with previously obtained results through perturbative calculations. In addition to that we also could extract several inertial modes.

- **Evolution of General relativistic, truncated post-Newtonian Taylor and Padé neutron star models:**

  Given a Taylor series (S_n) of order n in an expansion parameter, its Padé approximant is written as the ratio of rational functions such that the sum of the order of these polynomials is n (order of Taylor series) and Taylor expansion of this Padé form to the order n is equivalent to the corresponding Taylor series (S_n) itself. In the context of some recent studies to estimate the relevant functions in the gravitational wave data analysis applications and to analyze the transition from the inspiral to the plunge in binary black hole coalescence, faster convergence properties of Padé approximants are observed.

  Keeping this in view, we have constructed Padé approximants to the truncated post-Newtonian (Taylor) neutron star models and have investigated their performance with Taylor truncated models and exact general relativistic neutron star models. The purpose of this study was to explore the possibility of having an improved post-Newtonian method to provide more accurate initial data for the final merger and coalescing phase of inspiralling binary neutron stars and black holes. Recently, Shinkai constructed a single neutron star model using post-Newtonian approach as a preliminary step towards this and showed that the second order 'post-Newtonian Taylor series' approximation is close enough to describe a general relativistic single star.

We have shown that the second order Padé solution for a single neutron star equilibrium configuration converges to the exact GR solution much faster as compared to the second order as well as the third order Taylor truncated models. Evolution of Padé initial data also confirm this. Even for the models quite close (approx. 5 % away) to maximum mass limit Padé data evolves much longer than the corresponding Taylor models. The Hamiltonian constraint remains less than 10^{-3} of $16\pi\rho$ throughout the Padé evolutions of various order.

Despite the fact that these studies were done for a single star as one dimensional system, similar behaviour of Padé approximants could be expected for binary systems or a rotating neutron star/black hole. The behavior of Padé approximants for such systems is under investigation.

- **Effects of rotation and equations of state on the structure of magnetic field for compact objects:**

  We have studied the effects of rotation under slow rotation approximation using Hartle-Thorne (HT) metric which treats rotation as the perturbation on a spherical symmetric non-rotating star, keeping the corrections up to second order in angular velocity. The considered models are described by pure *quark matter* (MIT Bag model), neutron rich matter (Wiringa, Walecka, Bethe-Johnson, Pandharipande and Sahu et al. equations of state) and as a hybrid star (quark core + neutron rich crust).

  External fields are derived analytically using an ansatz (taking the magnetic field to be a dipole and electric field as a quadrupole), whereas the fields inside the stars.are obtained by integrating the equations from boundary to center. We have developed a code which integrates a non-rotating model, computes perturbed metric coefficients and solves Maxwell's equations for a given equation of state.

  We find that the magnetic field line density increases for the stiffer equations of state, which seems to indicate the necessity of higher fields to bind the matter configuration. The increase in the field strength from the star's surface to a distance of 0.1 km from the center is almost of six orders which are quite consistent with the order of calculations by Shapiro and Lai for neutron star models. This is further enhanced due to rotation – $\sim 30\%$ near the center and 10% near the surface for stiffer EOS – as compared to the corresponding non-rotating models.