When further results lead to shapes that permitted access to space the NACA was replaced by the National Aeronautics and Space Administration (NASA) and research related to both aircraft and spacecraft continues at the Langley Research Center.

VARIABLE GEOMETRY AIRCRAFT. M. Leroy Spearman. NASA-Langley Research Center. Hampton, VA . A given aircraft design is generally a fixed shape that fits the mission requirement and different requirements require different shapes. Since the early days of manned flight aircraft have generally had a lift-producing wing that was aligned normal to the airstream direction. As the air moves over the wing surface the air begins to compress and with increased speed a point is reached where the air cannot be moved any further and increased flight speed is not possible. By sweeping the leading edge of the wing back at an angle to the flight direction the air flow over the wing travels a greater distance from the wing leading edge to the trailing edge and this apparent slimming delayed the onset of compressibility. While swept wing designs did permit high speeds they had poor stability at low speeds that required translating the wing fore and aft as the sweep angle was changed. NASA Langley resolved the problem with a design in which only a portion of the wing was swept. This lead to the concept that a wing with variable sweep could combine the speed advantage of high sweep with the good stability characteristics of low sweep. In 1961 the U.S. Secretary of Defense, Robert McNamara initiated the Transonic Experimental Fighter (TFX) program to develop a common airframe suitable for the Navy and the Air Force. The General Dynamics F-111 airplane was produced that met the mission requirements but the Navy cancelled out because the airplane exceeded weight and size limits imposed by aircraft carriers. Other airplanes that have made use of variable sweep in the U.S. are the Navy Grumman F-14 and the Air Force Rockwell B-1.

Astronomy, Mathematics and Physics / Materials Science

AN INEXPENSIVE RADIO TELESCOPE IN A COLLEGE PHYSICS LAB. T.C. Mosca III, Dept. of Mathematics & C. Crook Dept. of Chemistry and Physics, Rappahannock Community College. An amateur radio telescope was established on the Glenns campus of Rappahannock Community College. The components included a commercial amateur radio receiver, an antenna designed to operate in the 15-30 MHz range, and a laptop computer running a freely available software package. Data were collected in 24-hour increments at 20.100 MHz, which is a frequency reserved for radiotelescopy. Numerous events were recorded, several of which were simultaneously observed at sites up to 3000 km away, indicating that these events originated from extraterrestrial sources. Physics students experienced a tangible application of electromagnetism principles, and learned that extraterrestrial objects are radio emitters. They also learned that real and valid research can be conducted without sophisticated and expensive equipment. In the future, we hope that students can be more directly involved in the collection and analysis of data, and that data can possibly be collected from sources other than our sun.

THE ACCELERATING JET OF 3C 279. S. D. Bloom[1], C. M. Fromm[2], and E. Ros[3], [1]Department of Physics & Astronomy, Hampden-Sydney College, [2]Max Planck

Institute for Radio Astronomy, [3]University of Valencia. Analysis of the proper motions of the sub-parsec scale jet of the quasar 3C 279 at 15 GHz with the VLBA shows significant accelerations in four of nine superluminal features. Analysis of these motions is combined with the analysis of flux density light curves to constrain values of Lorentz factor and viewing angle (and their derivatives) for each component. The data for each of these components is consistent with no changes to the Lorentz factor, but significant changes to the viewing angle and azimuthal angle, suggesting jet bending with minimal changes in speed. We see that for these observed components Lorentz factors are in the range of 10^{-36}, and for viewing angles of 0.1°-4.6°, and intrinsic (source frame) flux density, $F=(7 \times 10^{-8} - 1.6 \times 10^{-4})$ Jy. Considering individual components, the viewing angles vary in time from 1.2 to 1.4 in the case of C1 (the least extreme example) and vary from 0.06° to 1.4° in the case of C6 (the most extreme example). The intrinsic flux density varies by factors from 1.6 for C8 and 240 for C5. Theoretical analysis of the accelerations also indicates potential jet bending. In addition, for one component, C5, polarization measurements also set limits to the trajectory of the jet.

FORMATION OF RELATIVISTIC OUTFLOWS IN ADAF DISKS WITH SHOCKS. Truong V. Le[1], Cassandra Brown[1], Peter A. Becker[2], and Santabra Das[3], [1]Dept. of Physics, Governor's School for Science and Technology, [2]School of Physics, Astronomy & Computational Science, George Mason University, and [3]Dept. of Physics & Astronomy, Indian Institute of Technology Guwahati, India. We have developed a new self-consistent theory for the production of the relativistic outflows observed from radio-loud black hole candidates and active galaxies as a result of particle acceleration in hot, inviscid accretion disks containing standing, centrifugally supported isothermal shocks. Utilizing this model, we estimate the jet locations of 13 low-power radio-loud AGNs using the associated observed jet powers and their inferred mass accretions. Our results suggest that there is a direct correlation between the jet power and the Bondi accretion power, and that the jets location increases further away from the event horizon as the mass accretion rates and jets powers increases.

ON THE REDSHIFT DISTRIBUTION OF GAMMA RAY BURSTS IN THE SWIFT ERA. Truong V. Le[1] and Charles Dermer[2], [1]Dept. of Physics, Governor's School for Science and Technology, and [2]E. O. Hulburt Center for Space Research Naval Research Laboratory. A simple physical model for long-duration gamma ray bursts (GRBs) is used to fit the redshift (z) and the jet opening-angle distributions measured with earlier GRB missions and with Swift. The effect of different sensitivities for GRB triggering is sufficient to explain the difference in the z distributions of the pre-Swift and Swift samples, with mean redshifts of $\langle z \rangle \sim= 1.5$ and $\langle z \rangle \sim= 2.7$, respectively. Assuming that the emission properties of GRBs do not change with time, we find that the data can only be fitted if the comoving rate-density of GRB sources exhibits positive evolution to $z \approx 3 - 5$.

SEARCHING FOR INTERMEDIATE MASS BLACK HOLES WITH X-RAYS. Insuk Jang[1], Mario Gliozzi[1], Lev Titarchuk[1] & Shobita Satyapal[1], [1]School of Physics, Astronomy, and Computational Data Science, George Mason Univ., Fairfax VA. 22030. The black hole mass is a crucial parameter to shed light on the physics of

accretion. While the presence of stellar mass black holes (sMBHs) in binary systems and supermassive black holes (SMBHs) in the center of galaxies is widely accepted, the very existence of intermediate mass black holes (IMBHs) is still a matter of debate. It has been suggested that this type of black holes within the mass range of $M_{BH} = 10^2 - 10^5\ M_S$ may reside in Ultraluminous X-ray sources (ULXs) which are very bright off nuclear X-ray sources. Recently, a new method to constrain the mass of BH systems, based solely on X-ray data, was successfully used for sMBHs and SMBHs. Since the X-ray emission is thought to be produced by the same process (Comptonization) in all accretion objects, in principle, this method can be applied to estimate the mass of black holes in ULXs. We have carried out a systematic analysis of a sample of 43 ULXs with multiple X-ray observations and applied this novel method. Our preliminary results suggest that ~70% of the sample harbor IMBHs and indicate a good agreement between the values of BH mass obtained with this technique and those derived with different methods present in the literature.

STATUS OF NSU'S RAPID REPONSE ROBOTIC TELESCOPE AT FAN MOUNTAIN,VA. Carlos W. Salgado, Dept. of Physics, Norfolk State Univ., Norfolk, VA 23504. The Norfolk State University (NSU), 60 cm, Ritchey-Chretien, Rapid Response Robotic Telescope (RRRT) is located at Fan Mountain Observatory, Covesvillle, VA, about 15 miles south of Charlottesville, VA. It is a fully automatic and remotely controllable telescope, initially equipped for UBVRI photometric studies. The RRRT is used for observational study of compact stars (and their progenitors), and in particular, the early photometry and polarimetry of Gamma-ray Optical Afterglows (GRB-OA). This telescope is part of the Swift follow-up team. The RRRT is a low inertia telescope (fast slew), dedicated to the study of fast transient phenomena, with rapid imaging polarimetry capabilities. The RRRT is also a central part of our educational and public outreach projects. For example, the Back Bay Amateur Astronomers use the telescope, and helped to build it. Furthermore, the RRRT and its data are available to NSU students and other students from the Tidewater area of Virginia. Such users include those at UVa, GWU, ODU, CNU, and JMU.

WHAT WE CAN LEARN ABOUT QUANTUM CHROMODYNAMICS (QCD) STUDYING THE MESON SPECTRUM. Carlos W. Salgado, Dept. of Physics, Norfolk State Univ., Norfolk, VA 23504. The study of the hadron spectrum led more than forty years ago to the development of the quark model, where baryons and mesons are described as bound (by a strong interaction) systems of three quarks and of a quark-antiquark pair, respectively. As a component of the current "Standard Model" of particle physics, Quantum Chromodynamics (QCD) is the accepted theory of the strong interactions. While much progress has been made in understanding QCD at high energies, strong interactions at the energy regime where hadrons are bounded (confinement) have remained obscure. A clear understanding of this regime is essential, since it is where the strong interactions are dominant (quark are confine into hadrons). While the original quark model still holds and has been proven to reproduce many features of the hadron spectrum, now we know that there are many more aspects (as hadron masses and spins) that cannot be explained only in terms of quarks. The dynamics of strong interaction fields (the QCD's gluons) plays a crucial role. Mesons, being made by the minimum possible aggregate of quarks (a quark - anti-quark pair),

are the simplest quark bounded system and therefore an ideal bench to study the interactions between quarks, to understand the role of gluons, and to investigate the mechanism of confinement. In this talk, we will outline how the modern study of the light-mass meson spectrum can provide information on those topics. New meson spectroscopy experiments planned for the future upgrade of Jefferson Lab will be also described.

AN ASSESSMENT OF DELIVERY METHODS IN TEACHING UNDERGRADUATE STATISTICS BY DISTANCE LEARNING. T.C. Mosca III, Dept. of Mathematics, Rappahannock Community College. Distance learning is sometimes criticized as being less effective than traditional methods because the teacher is not physically present in the room with the students. In the fall semester of 2011 I taught three sections of MTH 240 Statistics that were nearly identical. The classes differed only in the amount of face-to-face time. One class section was online; there was no face-to-face time. The others were two sections of a hybrid class. The hybrid class met once per week by two-way interactive audio and video connection. One section met face to face three times per month, and the other class section met face to face one time per month. Class meetings and additional lessons were recorded. Students in the online class were provided both sets of recordings. All students received exactly the same instruction, with the only difference being the amount of face-to-face time for each section. The proportions of students who were successful vs. the proportions who failed or received a grade of "D" in each section were compared using a Chi-squared multiple comparison routine. Numerical grades were compared using ANOVA. The hypothesis that face-to-face time is a determining factor in student success was not supported.

MEASUREMENTS OF STELLAR POLARIZATION USING THE VMI OPTICAL POLARIMETER. Gregory A. Topasna & Daniela M. Topasna, Department of Physics and Astronomy, Virginia Military Institute, Lexington, VA 24450. We have designed and built an optical polarimeter for use with the Virginia Military Institute's 0.5 meter telescope. The polarimeter uses an achromatic half-wave plate and Wollaston prism to image the ordinary and extraordinary rays onto a CCD camera after the light passes through a B, V, R, or I filter. Aperture photometry is performed to determine the flux for the ordinary and extraordinary stellar images and the normalized Stokes parameters with their associated uncertainties. Observations of unpolarized stars are used to determine instrumental polarization and highly polarized stars are used to determine the instrumental zero-point reference. We present an analysis of the polarimeter and its performance characteristics.

COMPARATIVE STUDY OF SELF-ASSEMBLED POLYMER THIN FILMS. D. M. Topasna, A. R. Firehammer, & G. A. Topasna, Department of Physics and Astronomy, Virginia Military Institute, Lexington, VA 24450. We fabricated multiple layer polymer thin films using a layer-by-layer self-assembly method by automated and manual fabrication. The films were characterized by UV-VIS-NIR and SEM measurements for a range of thickness values. The characterization results demonstrate that both methods yield films with similar optical and physical properties.

ERROR LIMITS, PADE APPROXIMANTS, AND POLE EXTRACTION FOR POWER SERIES. Joseph D. Rudmin, Dept. of Integrated Sci. and Tech., James Madison Univ., VA 22807. George Edgar Parker and James Sochacki have shown how to find, to any order, the Taylor Series approximation to a system of differential equations, if it exists. They and Paul and Debra Warne and David Carothers derived concise closed-form absolute error limits for this method. For most practical applications, a Padé approximant derived from the Taylor Series provides better fit than the Taylor Series. However, both Taylor Series and Padé Approximants have difficulty modeling poles in the solution. Often one can best model a pole by a change of variable, where the variable explicitly contains the pole. The change of variable can be found from the differential equations by eliminating the highest order feedback loop in the Parker Sochacki approximation, thus simplifying those equations.

TESTING A NEW METHOD FOR ESTIMATING BLACK HOLE MASS IN LOW LUMINOSITY ACTIVE GALACTIC NUCLEI. Christina L. Hughes & Mario Gliozzi, Dept. of Physics & Astronomy, George Mason Univ., VA 22030444. Black holes have recently become a primary topic in astrophysics as it is now known that each galaxy harbors one supermassive black hole at its center. Finding the mass of these black holes is critical to understanding the physical conditions around black holes and to shed light on the cosmological evolution of galaxies. Among techniques devised to determine black hole mass, dynamical methods are considered the most reliable. Unfortunately, such methods have severe limitations (they can be applied only on nearby galaxies) and have led astronomers to seek more far-reaching, universal methods. One recently proposed method relies on the ubiquity of the X-ray radiation in black hole systems produced by the Comptonization process and on the analogy between stellar and supermassive black holes. Recently, this method has been successfully applied to black hole systems accreting at a high rate, but has yet to be tested on low-accreting systems. This project explores the limitations of this X-ray based method by applying it to sizeable sample of low accreting black holes whose mass is known via dynamical methods and which possess high-quality X-ray data. In addition to preliminary research in astrophysics literature, this project encompasses data reduction of archival Chandra satellite observations as well as the analysis of spatial and spectral properties of each object. Both analytical and statistical techniques, applied in conjunction with an understanding of the physical processes at work, were used to ascertain calculated masses. The results of this project will provide a general understanding of the applicability and/or limitations of this method.

Biology
with Microbiology and Molecular Biology

CONTRIBUTIONS OF CELL DIVISION AND CELL DEATH TO GROWTH AND METAMORPHOSIS OF PHARYNGEAL ARCH CARTILAGES IN THE FROG *XENPUS LAEVIS.* W. T. Koch, V. K. Horne, & C. S. Rose, Department of Biology, James Madison University, Harrisonburg VA 22801. The pharyngeal arch cartilages of *Xenopus laevis*, including the lower jaw or Meckel's cartilage (MC) and the ceratohyal (CH), grow isometrically at tadpole stages and undergo radical shape