PHYSICS AND ASTRONOMY

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ABSTRACTS

A Novel 360° Hologram. Karen G. Ferguson, Bradley A. Silburt, Doreen Wiley and F.R. Steldt, Indiana University at Kokomo, Kokomo, Indiana 46902.——A 360° hologram can be modified so that two distinct images appear when the finished hologram is viewed. The images are located at the same point with respect to the film and its holder. The images are produced by first making a conventional 360° hologram of an object. The film is then reinserted so that the top edge of the film was the bottom edge of the first trial. In essence, this would correspond to being positioned upside down. A second exposure is made again using a different object. When the film is developed and viewed, both images can be seen. In order to observe the other image, the film must be turned over as it was previously during the double exposure.

Holographic Interferometric Vibration Studies. Uwe J. Hansen, Department of Physics, Indiana State University, Terre Haute, Indiana 47809; Scott Hampton and Thomas D. Rossing, Department of Physics, Northern Illinois University, DeKalb, Illinois 60115.——Phase coherence between reference and object beams in holography is critical to within a fraction of a wavelength. Where random fluctuations during hologram exposure render hologram recordings ineffective, regular periodic motion results in marked interference fringes with the displacement related to the number of observed fringes. This phenomenon makes it possible to observe resonant modes of vibrating systems.

We report mode identification studies on G4, F6 and D7 handbells. Manufacturers routinely cast handbells with a stem at the crown, identified as the tang, facilitating the machining and tuning of the bell. The present work includes studies of the influence of the tang on the resonant frequencies and mode shapes for these bells. Mode patterns indicate no significant encroachment into the crown area and thus no musically interesting influence of the tang on bell tone quality.

Modal Analysis Studies of Guitars. Uwe J. Hansen, Department of Physics, Indiana State University, Terre Haute, Indiana 47809; John Popp, Moraine Valley Community College; Palos Hills, Illinois 60465; Thomas D. Rossing, Department of Physics, Northern Illinois University, DeKalb, Illinois 60115; William Y. Strong, CBS Technology Center, Stamford, Connecticut 06905.——The mechanical responses of a Martin D-28 folk guitar and a Kohno classical guitar have been studied under impulsive excitation, using a Hewlett Packard Fast Fourier Transform Analyzer, and the SMS Modal 3 modal-analysis software package. The acoustically significant, low-frequency modes will be discussed and observed on a video monitor.

Chromospheres of Red Giant Stars. HOLLIS R. JOHNSON, Department of Astronomy, Indiana University, Bloomington, Indiana 47405; THOMAS B. AKE, Space Telescope Science Institute, Johns Hopkins University, Homewood Campus, Baltimore, Maryland 21218; and JOEL A. EATON, Department of Astronomy, Indiana University, Bloomington Indiana 47405.——We report an extensive investigation of the chromospheres of the coolest red giant stars—these of spectral types M, N, R and S—from ultraviolet spectra taken with the NASA International Ultraviolet Explorer (IUE) satellite.

Spectra of early R stars show no emission features nor any indication whatever of chromospheres. Weak Mg II emission is detected in R8 stars, but only because of the extreme weakness of the continuum at 2800 A. The warmer ($\sim$3000 K) N stars show weak emission from Mg II, C II, and Fe II indicative of chromospheres but not coronas. Ultraviolet spectra of the warmer S stars have spectra similar to cool M giants, indicative of extensive chromospheres, while cooler S stars have spectra more similar to N-type stars. Altogether the spectra generally indicate chromospheres (which may vary with time) but not coronas. Some evidence suggests complex, non-homogeneous outer atmospheres.

Non-linear Differential Equations and Symbolic Manipulation in Physics. SAMIR I. SAYEGH, Department of Physics, Indiana University-Purdue University at Fort Wayne, Fort Wayne, Indiana 46805.——This paper deals with techniques of attacking non-linear differential equations. The first such technique is an extension of Sophus Lie's work on continuous symmetry groups of differential equations and is designed to solve or simplify such equations through the reduction of their order. For a second order equation for example, two such reductions, performed simultaneously or sequentially, lead to quadrature. The second technique deals with the Painleve property and its relation to stability.

An invaluable tool for effectively applying these techniques is the symbolic manipulation computer languages (REDUCE, MACSYMA, SMP) that allows one to carry out non numerical calculations. A REDUCE program is presented that systematically searches for symmetry groups of a large class of non-linear differential equations allowing reduction in the majority of the cases. Two examples are given that illustrate the power of the method and its usefulness in physical applications.

Thermal Energy Reclamation from Industrial Process Wastewater. MICHAEL R. WITTY AND RONALD M. COSBY, Department of Physics and Astronomy, Ball State University, Muncie, Indiana 47306.——The wastewater treatment process at the Anderson, Indiana DelcoRemy complex was analyzed for potential thermal energy reclamation. Site visits concluded that the clearwell reservoir water be used as the thermal energy source. The clearwell water has a flowrate of 870 ± 30 gallons per minute at a temperature of 80 ± 4 degrees Fahrenheit. The proposed heat recovery system utilizes a heat exchanger and two industrial heat pumps in a series-counterflow arrangement, recovering 10 million BTU per hour with a COP of 5.9. It is proposed that the recovered energy be used to raise the temperature of boiler feed water from 55 degrees to 157 degrees Fahrenheit. Utilizing the recovered energy in this manner could produce an annual savings of $220,000. This study recommends that Delco Remy pursue the installation of a heat-pump based thermal reclamation system to recover otherwise wasted energy from industrial waste water.

Numerical Evidence for Fractal Basin Boundaries for the Duffing Oscillator. KEVIN YAUSSY,* Manchester College, North Manchester, Indiana 46962 and ROGER ROLLINS AND E.R. HUNT, Ohio University.——The motion of a particle in a two-well poten-

tial with viscous damping and a harmonic forcing function is studied. We use the fourth-order Runga-Kutta method on a 16 bit microcomputer with a math co-processor. The parameters are chosen such that any initial state eventually settles into one of four periodic orbits each of which is a possible final state. We find the boundary of the set of initial conditions which results in any one periodic orbit appears to be a fractal. This is an example of obstructions to predicting the final state even in non-chaotic dynamics of nonlinear systems.[1]

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[1]C. Greboyi, S.W. McDonald, E. Ott and J.A. Yorke, Phys. Lett. *99A*, 415 (1983).