Laser Phase and Frequency Stabilization Using an Optical Resonator

R. W. P. Drever, J. L. Hall, F. V. Kowalski (USA), J. Hough, G. M. Ford, A. J. Munley, H. Ward (Scotland)

We describe a new and highly effective optical frequency-discriminator and laser stabilization system based on signals reflected from a stable Fabry-Perot reference interferometer. High sensitivity for detection of resonance information is achieved by optical heterodyne detection with sidebands produced by rf phase modulation. Physical, optical, and electronic aspects of this discriminator/laser frequency stabilization system are considered in detail. We show that a high-speed domain exists in which the system responds to the phase (rather than frequency) change of the laser; thus with suitable design the servo loop bandwidth is not limited by the cavity response time. We report diagnostic experiments in which a dye laser and gas laser were independently locked to one stable cavity. Because of the precautions employed, the observed sub-100 Hz beat line width shows that the lasers were this stable. Applications of this system of laser stabilization include precision laser spectroscopy and interferometric gravity-wave detectors.

Electromagnetic Induction in Conductors Accelerated in Magnetic Fields, Amplified by Flux Compression

H. E. Wilhelm (USA)

The initial boundary-value problem for the electromagnetic induction in a conducting slab at $s(t) \leqq x \leqq s(t) + a$ resulting from its accelerated motion $\mathbf{v} = \{\dot{s}(t), 0,0\}$ across a transverse magnetic field $\mathbf{B} = \{0,B(x,t),0\}$ is treated, when the latter is amplified by orders-of-magnitude with respect to its initial value $\mathbf{B}(x,t=0)\mathbf{B}(x)$ by flux compression in the gap between the moving conductor surface $x = s(t)$ and an ideal resting conductor at $x = 0$. Two initial ($t = 0$) configurations are considered, assuming that (I) $\mathbf{B}_0$ (step-shaped) has not yet and (II) $\mathbf{B}_0$ (uniform) has completely diffused into the conductor at $x = s\ (t = 0)$. By means of a time-dependent coordinate transformation $\xi = [x\text{-}s(t)]/a$ and Fourier series expansions, the electromagnetic fields in the moving conductor are represented as integral-functionals of the magnetic field $B_1(t)$ in the gap $0 \leqq x \leqq s\ (t)$. $B_1\ (t)$ is given analytically as solution of a singular Volterra integro-differential equation. The theory is valid for arbitrary (nonrelativistic) speeds $\dot{s}\ (t)$ and accelerations $\ddot{s}\ (t)$ of the moving conductor. Applications to explosion driven electric induction generators and magnetic flux compression experiments are discussed briefly.

Amplification and Measurement of Single 1,6-3,5 ps Pulses Generated by a Distributed Feedback Dye Laser

G. Szabó, Zs. Bor (Hungary), A. Müller (F. R. Germany)

We have shown that distributed feedback dye lasers are capable of generating single transform-limited pulses of 1.6-3.5 ps duration when pumped by a mode-locked Nd: YAG laser. A short-pulse amplifier has been constructed in which the level of amplified spontaneous emission could be kept below 10^{-3} by properly taking into account the polarization anisotropy of the gain and by precise timing of the pump pulses. A sensitive autocorrelator is described which allows to measure pulse duration in a single shot.

Thermochemical Instability of Transparent Media Induced by an Absorbing Inclusion

S. M. Golberg, G. A. Matyushin, N. F. Pilipetsky, S. Yu. Savanin, A. N. Sudarkin, M. I. Tribelsky (USSR)

The initial stage of thermochemical instability induced by an absorbing inclusion within a transparent matrix which irradiated by a laser beam is studied. The instability results in a low threshold (formally non-threshold) optical breakdown of the matrix. It is brought about by the additional absorption of the laser light by the products of the chemical reactions in the matrix. The instability is characterized by a certain induction time when the rate of the chemical reactions is almost steady. When the induction is over, their rate rapidly increases. Theoretical estimate of the induction time are offered. The experimental study of the induction time dependence on the laser-beam intensity confirmed the theoretical estimation.

Continued on page A6

Applied Physics A 30, No. 4 (1983)

Invited Paper

Contributed Papers

Cars Spectra of Thermally Excited SF_6 Molecules

A. A. Puretzky, V. N. Zadkov (USSR)

CARS spectra of the γ_1 mode of thermally excited SF_6 were calculated numerically. The influence of the vibrational quasicontinuum on the CARS spectra has been considered by introducing different types of the homogeneous broadening at different vibrational levels. The appearance of additional lines in the CARS spectrum due to mixing of high-lying vibrational levels by Fermi coupling was considered numerically in the frame of a simple model. A comparison of calculated and experimental spectra has been made.

Dressed-Atom Approach for Probe Spectroscopy, in Doppler-Broadened Three-Level Systems with Standing-Wave Saturator

L. Roso, R. Corbalán, G. Orriols, R. Vilaseca (Spain), E. Arimondo (Italy)

The three-level probe spectroscopy of Doppler-broadened transitions in the presence of a standing wave pump laser is investigated through a diagrammatic method. A probe-response diagram is defined where the resonance positions versus the probe laser frequency and absorber velocity are plotted. The dressed atom description provides a convenient method for deriving the probe response diagram and calculating the position of the Doppler-free structures on the absorption spectrum, including the ac Stark shifts. We have interpreted probe spectra on the basis of the probe response diagram, presenting new features and giving a detailed physical interpretation of all the coherent effects appearing in the spectra. Population effects are not included in the dressed system analysis and are calculated on the basis of a semiclassical treatment, but the probe response diagram provides a complete interpretation of the involved phenomena.

Mass Spectrometry of High Pressure Arcs in Air and SF_6

W. Rüegsegger, F. K. Kneubühl, H. J. Schötzau (Switzerland)

For the development of SF_6 pufferbreakers it is important to gain insight into the chemical composition of the SF_6 gas during the high-current period as well as close to current zero. For this reason a mass-spectrometric sampling system is presented which allows dynamic measurements of chemical reactions occuring in high-pressure arcs. Results of mass-spectroscopic investigations on a dc and a pulsed arc are presented.

FIR NH_3 Cascade Laser Excited by a Q-Switch Laser

J. W. Won, G. D. Willenberg (F. R. Germany)

Short FIR laser pulses of high repetition rate are obtained by pumping NH_3 with the pulses of a passively Q-switched ir laser. The two cascade laser transitions observed show coupled relaxation oscillations. The pulse shapes and delay times are qualitatively in agreement with a four-level rate-equation model.

Amplified Phase-Conjugate Reflections, of $\lambda = 10.51$ μm Radiation in Gaseous SF_6

L. T. Bolotskikh, A. K. Popov (USSR)

Phase-conjugate reflection at the $P(12)$ CO_2 line ($\lambda = 10.51$ μm) has been obtained in gaseous SF_6 with a power reflection coefficient of 220% and an energy reflection coefficient of 115%.

Nonlinear Waves Guided by a Dielectric Slab TE-Polarization

F. Lederer, U. Langbein, H.-E. Ponath (DDR)

We consider dispersion relations and field structure of TE-polarized guided waves travelling along an asymmetric dielectric slab surrounded by two different nonlinear media. For a given configuration there are four types of guided waves. Three of this four types possess at least one field maximum outside the slab region and have no counterpart in linear waveguide optics. The solutions of the dispersion relations depend now on an additional parameter making them more flexible with respect to the linear limit.