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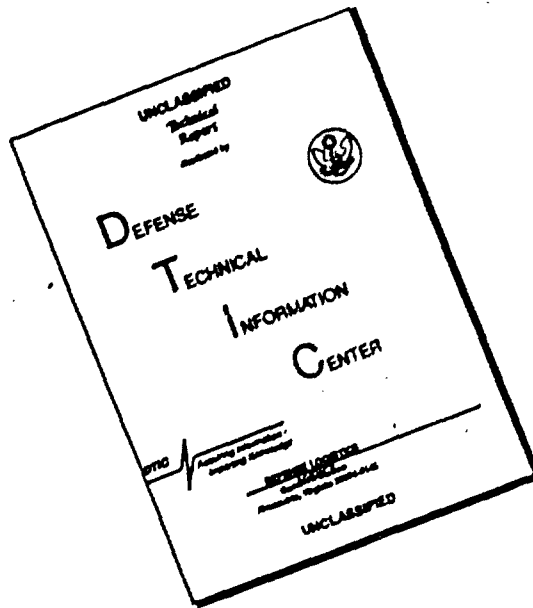
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PLASMA SPECTROSCOPY

Annotated Bibliography

(AID Work Assignment No. 43, Task 1)

Aerospace Information Division
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FOREWORD

This bibliography, prepared in response to AID Work Assignment No. 43, Task 1, is intended as a guide to Soviet literature on plasma spectroscopy. It has been compiled from three Soviet journals, spanning the period March 1958 to November 1962, available at the Aerospace Information Division.

The 112 entries, comprising 117 separate articles, are arranged alphabetically by author. An annotation is provided for each article.

The Library of Congress call numbers for the three journals exploited are as follows:

Akademiya nauk SSSR. Izvestiya. Seriya
fizicheskaya (4 issues) AS262.A62455
Optika i spektroskopiya (40 issues) QC350.068
Zhurnal tekhnicheskoy fiziki (15 issues) QC1.Z48

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PLASMA SPECTROSCOPY

1. Afrosimov, V. V., V. A. Glukhikh, V. Ye. Golant, A. N. Zaydel', Ye. G. Komar, B. P. Konstantinov, G. M. Malyshev, I. F. Malyshev, N. A. Monoszon, A. M. Stolov, and N. V. Fedorenko. The "Al'fa" installation in plasma investigations. Zhurnal tekhnicheskoy fiziki, v. 30, no. 12, 1960, 1381-1393.

Pulse discharges in a toroidal chamber are investigated by using vortex electric fields. The magnetic measurements are made in hydrogen at pressures of $\sim 2 \cdot 10^{-4}$ mm Hg and frequencies of 9400 and 36,600 Mc, and spectrographs are employed to register spectral lines in the 500 to 5000-Å region. These lines indicate the presence of plasma impurities, such as O, N, and C, and of construction-material impurities, such as Al, F, and Si.

2. Akimov, Ye. M. (Deceased), and I. P. Malkov. Determination of vacuum spark temperature. Optika i spektroskopiya, v. 6, no. 1, 1959, 96-98.

Vacuum spark temperature is determined by utilizing the relative intensities of diffuse and principal series of Al III spectral lines. For that purpose a vacuum spectrograph with a pressure of 10^{-3} mm Hg is used. Measurements show that the spark temperature is 45,000°K for wavelengths of 1862.9 and 1605.7 Å and 47,000°K for 1854.67 and 1605.7-Å wavelengths.

3. Alyamovskiy, V. N., and V. F. Kitayeva. Hydrogen (H_{β}) line contour in argon behind the shock wave. Optika i spektroskopiya, v. 8, no. 2, 1960, 152-156.

A shock tube and a mixture of hydrogen and argon at pressures ranging from 0.3 to 3.0 mm Hg are employed in the experiments. Shock wave velocities range from 3.6 to 4.8 km/sec and the temperatures and pressures behind the reflected waves, from $\sim 12,000$ to $13,000^{\circ}$ K and from 0.5 to 1.5 atm. The data show that within the limits of accuracy of the experiment the experimental data agree with analytically computed ion-concentration magnitudes in plasma.

4. Bakakina, V. V. Some results of a uhf-discharge-spectrum investigation in a restricted discharge gap. Optika i spektroskopiya, v. 9, no. 6, 1960, 784-786.

Discharges in helium and neon are investigated in a restricted discharge gap. The discharge is excited by powerful uhf pulses at pressures ranging from 1 to 100 mm Hg. Spectral-line intensities are observed with a monochromator. The study confirmed that 1) neon and helium line intensities follow very closely the amplitude changes in the uhf sources at 5 and 10 mm Hg, respectively; 2) the intensity of a quasi-stationary impulse period falls off with pressure increase; 3) some spectral lines, especially in the vicinity of the 4143-A line, possess a perceptible background at pressures over 20 mm Hg; and 4) with an increase in pressure two light bursts of high intensity are present, the duration of the first being $< 0.5 \mu\text{sec}$ and that of the second considerably longer, whose amplitudes depend on pressure and line characteristics.

5. Bamberg, Ye. A., and S. V. Dresvin. Temperature of an air-stabilized torch discharge. Zhurnal tekhnicheskoy fiziki, v. 32, no. 6, 1962, 772-774.

The investigation is conducted by studying the relative intensities of the spectral lines of iron. The temperature measurements, taken at two points 50 mm apart, give $\sim 3900^\circ\text{K} \pm 200^\circ$.

6. Belousova, I. M. Formation mechanism of equilibrium concentration of the electrode substance in a plasma arc discharge. Optika i spektroskopiya, v. 13, no. 1, 1962, 12-19.

An analytical and experimental study is made in which the relative and absolute particle concentrations and the degree of ionization are evaluated by utilizing the measurements of spectral-line intensities and electron concentrations. The measurements are conducted in an arc of constant current (5 amp) preheated by a pulse current of 100 amp at pressures ranging from 10 to 760 mm Hg. The arc burns in air containing definite amounts of Ba, Fe, Na, and Cu. The data show that when the discharge takes place the electrode substance concentration decreases with a decrease in pressure, and that the time in which the equilibrium space distribution of particles in space is established is of the order of 10^{-4} sec.

7. Belousova, I. M., and D. B. Gurevich. Distribution of atoms in regard to their excited levels in an arc at low pressures. *Optika i spektroskopiya*, v. 10, no. 3, 1961, 410-412.

The distribution of energy levels is investigated for iron and barium at pressures ranging from 20 to 760 mm Hg. For that purpose, a spectrum is excited in an arc between two carbon electrodes with a direct current of 5 amp. It is shown that at pressures above 100 mm Hg the level populations obey the Boltzmann law and the gas and electron temperatures coincide; at pressures below 100 mm Hg the level populations do not obey the Boltzmann law and the gas temperature decreases.

8. Belousova, I. M., and D. B. Gurevich. Mercury-arc temperature calculation and its experimental verification. *Zhurnal tekhnicheskoy fiziki*, v. 31, no. 11, 1961, 1337-1343.

Mercury-arc temperatures on the discharge axis and their cross-section distributions are calculated by the Maecker method. By utilization of a spectrograph the discharge-axis temperature is evaluated from the intensities and energies of 5790.66 and 4916-Å spectral lines. It is concluded that the Maecker method is a reliable one for temperature determination in a mercury-arc discharge.

9. Bochkova, O. P., L. P. Razumovskaya, and S. E. Frish. Spectroscopic investigation of an hf discharge in neon. *Optika i spektroskopiya*, v. 11, no. 6, 1961, 697-705.

Optical and electrical characteristics of an electrodeless hf discharge in neon are investigated at 6 Mc in discharge tubes varying from 130 to 300 mm in length. Populations of the lower neon levels are evaluated by means of the reabsorption method. The electrical discharge parameters, such as electron temperature and electron concentration, are evaluated by using the sample method. The data show that 1) the hf discharges exhibit high concentrations of excited atoms; 2) for the stationary processes the level populations depend on the equilibrium between the excitation and destruction phenomena per unit of time; and 3) hf discharges are well adapted for the spectral analysis of gas.

10. Bonch-Bruyevich, A. M., and A. V. Yelizarov. Double luminous layers occurring in hf discharges in hydrogen. *Optika i spektroskopiya*, v. 4, no. 3, 1958, 289-295.

Discharges of 1 to 10 Mc were introduced into glass tubes filled with hydrogen, and luminous layer images were projected into the aperture of a spectrograph. Electrode intensities varied from 0 to 2000 v. The following data were obtained. 1) At current densities $> 5 \cdot 10^3$ amp/cm² the discharge space is filled completely with uniform light. 2) A decrease in current density leads to the appearance of a dark area in the middle of this space and finally to the formation of relatively stable two-layer strata. 3) Application of an external magnetic field perpendicular to the discharge-tube axis brings about an increase in the number of layers.

11. Charnaya, F. A. Investigation of instantaneous brightness of a pulse discharge channel. *Optika i spektroskopiya*, v. 4, no. 6, 1958, 725-733.

Electrical parameters and the spectral density of energy brightness are investigated in spherical pulse lamps filled with Ar, He, Xe, Kr, Ne, N, and O₂ gases at pressures ranging from 1.5 to 18 atm. Pulse and standard lamps are combined with photomultipliers, oscillographs, and an appropriate optical system. The maximum magnitudes of spectral density brightness of a pulse discharge channel were found to be constant for all the gases except He and to decrease with an increase in the atomic weight of the gas; maximum brightness was found to increase with an increase in the atomic weight of the gas.

12. Dolgov, G. G. Polarization of helium-atom radiation induced by electron impacts. *Optika i spektroskopiya*, v. 6, no. 6, 1959, 717-722.

Helium lines of 5016, 4921, 4471, and 3889 Å are studied at a working pressure of $2 \cdot 10^{-4}$ mm Hg. It is established that at energies exceeding by a few ev the excitation-energy thresholds the direct and cascade transitions from the higher levels begin to be prominent. The cascade transitions do not contribute more than 15% to the excitation effects of all the levels.

13. Dontsov, Yu. P. Isotopic shift in the molybdenum spectrum. Optika i spektroskopiya, v. 8, no. 4, 1960, 446-451.

Isotopic Mo spectra are excited in a discharge tube with a hollow cathode. The tube is filled with spectrally pure argon at a pressure of 0.5 mm Hg. The spectra, ranging from 4500 to 6400 Å, are recorded on photoplates. It was discovered that 1) the signs of isotopic shifts coincide, in 18 out of 20 lines, with the volume effect signs and with a maximum shift corresponding to a transition of two 5s electrons; and 2) isotopic shift anomalies in the spectra are connected with amplitude changes of zero vibrations of a quadrupole nuclear moment.

14. Dontsov, Yu. P., V. A. Morozov, and A. R. Striganov. Isotopic shift in a neodymium spectrum. Optika i spektroskopiya, v. 8, no. 6, 1960, 741-745.

Two mixtures, one of Nd^{142} , Nd^{146} , and Nd^{150} , the other of Nd^{144} , Nd^{148} , and Nd^{150} , are investigated by employing a Fabry-Perot interferometer and a discharge tube with a hollow cathode; argon serves as the working gas. Isotopic structures are measured by a comparator. Tabulated data, showing spectral shifts and relative spectral shifts versus wavelength for sixteen spectral lines of Nd I and Nd II, indicate that 1) there is no significant difference between the relative shift of Nd I and Nd II lines; 2) relative shift anomalies are independent of line wavelengths; and 3) neodymium spectra manifest nonequidistant isotopic shifts.

15. Dronov, A. P., A. G. Sviridov, and N. N. Sobolev. Study of the state of krypton behind a shock wave. Optika i spektroskopiya, v. 10, no. 3, 1961, 312-321.

The energy state of krypton behind a shock wave is investigated in a shock tube by analyzing the krypton, xenon, calcium, and hydrogen (H_{α} , H_{β}) spectral lines. An attempt was made to utilize the relative line intensities of hydrogen for measuring the plasma temperatures. However, this procedure proved to be difficult. It was found that concentrations of charged particles can be evaluated by studying the contours of H_{α} and H_{β} spectral lines.

16. Dunayev, Yu. A., G. K. Tumakayev, and A. M. Shukhtin. Application of the Rozhdestvenskiy method to investigation of gas-dynamic processes in shock tubes. Zhurnal tekhnicheskoy fiziki, v. 31, no. 9, 1961, 1119-1126.

A technique for applying the anomalous dispersion method is described, and mercury atom concentrations, gas stream temperatures behind shock waves, and f -values for some mercury lines are investigated. The interference phenomenon is recorded from mercury spectral lines with wavelengths ranging from 2500 to 5800 Å and from the mercury vapors behind the shock wave.

17. Dvornikova, I. V. Dependence of the total intensity of spectral lines on absolute concentration of atoms in an arc discharge. IN: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 22, no. 6, 1958, 677-680.

The interdependence of the reabsorption of spectral lines and the absolute atom concentrations in the space between electrodes has been experimentally and analytically investigated. The study is based on earlier research by Cowan and Dicke (Rev. Mod. Phys., v. 20, 1948, p. 418) indicating that an increase in atom concentration leads to an increase in spectral line reabsorption and to the broadening and self-reversal of the lines. The intensities of two triplet spectral lines of Cr in an arc discharge are observed and plotted in logarithmic form against the absorption and nonhomogeneity characteristics of the light source. The experimental curves agree to a large extent with the theoretical ones.

18. Dvornikova, I. V., and I. M. Nagibina. Determination of the degree of inhomogeneity in dc and ac arc discharges. Optika i spektroskopiya, v. 4, no. 4, 1958, 421-429.

Recent experimental data and the theory of Cowan and Dicke mentioned in the previous reference are employed in an investigation utilizing a Fabry-Perot interferometer and a high-dispersion spectrograph to introduce neutral atoms of Cr and Mn and ions of Ca and Sr into the arc at normal pressures. Measurements of various spectral-line parameters show that 1) the discharge cloud manifests a relatively small inhomogeneity for the neutral Cr and Mn atoms; 2) changes in burning-arc conditions, such as current values and atom concentration, lead to certain changes in inhomogeneity; and 3) the discharge cloud is more homogeneous for the ions than for the neutral atoms.

19. Fayzullof, F. S., and N. N. Sobolev. Effective cross-section determination of collisions of excited barium ions with argon atoms. *Optika i spektroskopiya*, v. 11, no. 5, 1961, 571-576.

It is proposed that second-order collisions be studied by measuring temperature with the spectral-line-reversal technique for nonequilibrium populations. Analytical equations are developed, into which the barium and argon magnitudes are introduced. The calculations indicate that argon demonstrates a very weak quenching effect, only slightly greater than zero.

20. Fayzullof, F. S., N. N. Sobolev, and Ye. M. Kudryavtsev. Spectroscopic investigation of the state of a gas behind a shock wave. II and III. *Optika i spektroskopiya*, v. 8, nos. 5 and 6, 585-593 and 761-768.

II. The spectral-line self-reversal method is employed. Tungsten temperature, xenon lamps, a monochromator, and the appropriate optical equipment are utilized for temperature evaluations based on Na D-lines. Changes in shock-wave velocity are measured by the ionization and other methods. The radiation characteristics of Na are found to be very similar to those observed by Clouston, Caydon, and Glass (*Proc. Royal Society A248*, 1958, p. 429).

III. The same method is applied to measure nitrogen, air, and argon temperatures behind a shock wave. In addition to the Na D-line, Ba II resonance lines are employed. The effective brightness temperature of the comparison source was 4750°K. The method is found to be effective, and the observational data are in agreement with theoretical deductions. It is concluded that state investigations of nitrogen and air behind a shock wave in the 1500 to 3000°K range can be conducted by measuring the Na D-lines and in the range above 3000°K by measuring Ba ion lines. In the experiments, measurement errors did not exceed $\pm 100^\circ$.

21. Fishman, I. S. Relation between self-absorption of spectral lines and their total intensity, and magnitudes of "b" for lines excited in a spark discharge torch. *Optika i spektroskopiya*, v. 13, no. 5, 1962, 630-634.

Analytical expressions are derived in a theoretical study. The "b"—intensity relationship is

then derived experimentally by measuring the spectral lines of nickel and copper, where η_b characterizes the spectral line absorption and is defined analytically as $[d \log I]/[d \log (Nlf)]$, N being atom concentration, l the thickness of the translucent layer, and f the oscillator strength.

22. Ginzburg, V. L., and N. P. Glukhovetskaya. Dependence of spectral-line intensities on the effective ionization potential of an arc. *Optika i spektroskopiya*, v. 12, no. 3, 1962, 344-349.

Pure carbon electrodes are used. Small, variable amounts of Na and K are introduced into the arc for measuring effective ionization potentials. Metallic elements, such as Pd, Ti, Fe, La, and Sb, are also introduced into the arc and their spectral-line intensities investigated. The data of the experiment show that 1) the spectral-line intensities of neutral and singly ionized atoms depend on temperature in accordance with theoretical evaluations made by Mandel'shtam in 1938, and 2) elements with different ionization potentials exhibit dissimilar plots of spectral-line intensity versus temperature.

23. Golant, V. Ye. UHF methods in plasma investigations. *Zhurnal tekhnicheskoy fiziki*, v. 30, no. 11, 1960, 1265-1319.

A systematic and detailed description, both analytical and experimental, of active methods (up to $1.5 \cdot 10^{11}$ cps) is given. Passive methods, based on the plasma radiation measurements, are not discussed. The article comprises the following subdivisions: 1) plasma conductivity in high-frequency fields; 2) resonance method; 3) wave-guide method; 4) method of heating an electron gas; 5) directed waves in plasma investigations; and 6) space dispersion of uhf waves for the investigation of plasma at high temperatures. An exhaustive list of references (over 96) is given.

24. Golant, V. Ye., N. I. Orlov, and L. P. Pakhomov. Obtaining high-density plasma by means of hot-cathode discharge in a magnetic field. *Zhurnal tekhnicheskoy fiziki*, v. 31, no. 7, 1961, 797-801.

A discharge chamber containing two tungsten electrodes is filled with hydrogen at a pressure of $5 \cdot 10^{-4}$ mm Hg and a working cathode temperature of 2000°C. The measurements are made in the presence

of uniform or nonuniform magnetic fields. The plasma beams are investigated from radio waves, and the electron energies in the discharge are investigated from the discharge spectra. Experiments demonstrated that 1) the discharge spectrum reveals the presence of doubly ionized carbon ions, indicating the existence of electrons with an energy of 20 to 30 ev; and 2) under the given conditions ($P = 5 \cdot 10^{-4}$ mm Hg min) and a magnetic field of 200 to 300 oe, the discharge can be maintained by voltages ranging from 50 to 100 v.

25. Gol'dfarb, V. M., and Ye. V. Il'ina. Determination of the diffusion coefficient and the mean lifetime of atoms in an arc-discharge plasma. *Optika i spektroskopiya*, v. 11, no. 4, 1961, 445-451.

Li, Na, and Ba atoms are investigated by utilizing a motion picture camera and an arc discharge. The latter is maintained by a direct current of 5 amp between the carbon electrodes. The compounds investigated are NaNO_3 , BaCO_3 , and Li_2CO_3 . Analytical formulas for the diffusion coefficients and atom concentrations in the arc are developed and found to be in satisfactory agreement with the experimental data.

26. Karbunov, Ye. P., G. G. Dolgov-Savel'yev, V. S. Mukhovatov, V. S. Strelkov, and N. A. Yavlinskiy. Toroid discharge investigation in a strong magnetic field. *Zhurnal tekhnicheskoy fiziki*, v. 30, no. 10, 1960, 1152-1164.

In the experiment initial deuterium pressures range from $2 \cdot 10^{-3}$ to $2 \cdot 10^{-4}$ mm Hg and magnetic field strengths from 2000 to 10,000 oe. The intensities of the deuterium, carbon, and hydrogen spectral lines and various electrical gas parameters and electron concentrations are measured. The data show that 1) the gas content of the walls influences plasma characteristics; 2) the appearance of spectral lines with variable energies demonstrates the growth of electron temperatures; and 3) greater magnetic field strengths correspond to greater plasma electric conductivities.

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27. Grechikhin, L. I. 4982.8-Å line broadening of sodium in the arc-jet of a direct current. Optika i spektroskopiya, v. 13, no. 4, 1962, 578-579.

Various zones of a dc-arc discharge are studied. The arc is maintained between two carbon electrodes, and the temperature is measured along the arc by the relative line intensities of the copper spectrum. The line width of the cathode jet is found to be greater than that of the anode jet in the near-electrode areas, and the concentrations of charged particles in the near-electrode zones to be greater in a cathode jet.

28. Grechikhin, L. I., and V. D. Shimanovich. Jet investigation of a plasma generator. Optika i spektroskopiya, v. 13, no. 5, 1962, 626-629.

Jet structure and temperature of a plasma generator are investigated by utilizing spectral lines of copper. The investigation shows that the luminous jet is supersonic and is responsible for the presence of high-intensity excitation lines.

29. Gromova, I. I., and S. A. Kulikov. Influence of current strength on hydrogen-spectrum intensity in the 1200 to 2500-Å region. Optika i spektroskopiya, v. 7, no. 1, 1959, 130-131.

High- and low-voltage hydrogen lamps are employed in a study which reveals that changes in current strength have different influences on the singlet and triplet states of a hydrogen molecule, and especially on the excitation of an atomic hydrogen spectrum.

30. Kagan, Yu. M., and Ya. P. Koretskiy. Direct method of measuring the mean lifetimes of excited levels of ions. Optika i spektroskopiya, v. 11, no. 3, 1961, 308-311.

The method utilizes an electron gun with a tube filled with helium at a pressure of 0.03 mm Hg. The He II spectral line of the 4686-Å wavelength is investigated by measuring the spectral-line shifts. The data show that the mean lifetimes derived from the observations are of the same order as those derived from quantum mechanical considerations.

31. Kashtan, M. S., E. V. Sobotovich, and T. N. Khlopina. Sensitivity increase of the spectral isotope analysis of lead. *Optika i spektroskopiya*, v. 8, no. 1, 1960, 23-26.

A discharge tube with a hollow cathode, a Fabry-Perot interferometer, and a spectrograph are utilized to evaluate samples containing microscopic amounts of lead. It was found that a content of 0.05 to 0.10 mg was sufficient for a dependable analysis and that the hollow cathode improves the dependability of the analysis.

32. Khokhlov, M. Z. Rotational temperature of hydroxyl and nitrogen and their excitation conditions in hf discharges. *Optika i spektroskopiya*, v. 4, no. 4, 1958, 438-447.

Changes in temperature of hf two-electrode and torch discharges in air at pressures ranging from 5 to 760 mm Hg are investigated for the 3064-Å hydroxyl and 3371-Å nitrogen spectral lines. The discharges are induced on brass electrodes; however, for torch discharges the upper electrode is absent. For pressures greater than 100 mm Hg the rotational temperatures of both hydroxyl and nitrogen coincide, while for pressures less than 100 mm Hg the hydroxyl temperature exceeds considerably that of nitrogen. Under pressures greater than 200 mm Hg the torch-discharge temperature is independent of the pressure and strength of the discharge. In general, certain conditions are present in torch and two-electrode discharges which permit the comparison of the rotational temperatures of hydroxyl and nitrogen under nonisothermal plasma conditions.

33. Kirillov, V. D. Radiation loss in gas-discharge plasma. *Zhurnal tekhnicheskoy fiziki*, v. 30, no. 3, 1960, 320-329.

A stable plasma column, not touching the walls of a discharge tube, is investigated. The tube, which contains copper electrodes, is filled with deuterium at pressures ranging from 0.01 to 0.2 mm Hg, with discharge-current amplitudes varying from 13 to 45 ka and longitudinal magnetic field strengths from 0 to 24,000 oe. By using a spectrograph, the amount of heat radiated and energy carried away by the Lyman spectral lines are evaluated for Al, Cu, Si, C, and H. The data show that the greatest part of energy absorbed by the plasma is lost through impurity radiation.

34. Kitayeva, V. F., V. N. Kolesnikov, V. V. Obukhov-Denisov, and N. N. Sobolev. Structure of arc-discharge column in argon. I. Zhurnal tekhnicheskoy fiziki, v. 32, no. 9, 1962, 1084-1089.

A mixture of argon (> 94%) and hydrogen (5%) is employed. Electric field intensities, charged-particle concentrations, and temperatures are measured to determine the structure. The concentrations are evaluated by measuring the contours of the H_{β} hydrogen-spectrum line for plasmas in the states of equilibrium and nonequilibrium. The data are in a good agreement with the magnitude derived from analytical equations.

35. Kitayeva, V. F., V. V. Obukhov-Denisov, and N. N. Sobolev. Concentration of charged particles in arc plasma burning in argon and helium atmosphere. Optika i spektroskopiya, v. 12, no. 2, 1962, 178-185.

Excitation processes and the establishment of level-population equilibria in argon- and helium-arc plasmas are investigated by examining the contours of H_{α} , H_{β} , H_{γ} , and H_{δ} spectral lines in a dc arc and in an argon-helium atmosphere. The observations are made at normal pressure and 1 to 200 amp. Experiments indicate that 1) changes in current between 6 and 200 amp correspond to charged-particle concentrations of $2 \cdot 10^{14}$ to $2 \cdot 10^{16}$ cm^{-3} in helium and $4 \cdot 10^{14}$ to $3 \cdot 10^{16}$ cm^{-3} in argon; 2) there should be a deviation from level-population equilibrium for small concentrations of charged particles in arcs and inert gases; 3) near-electrode portions of the arcs burning in argon and helium atmosphere contain higher concentrations of charged particles near the cathode and lower concentrations near the anode; and 4) the observational data are in good agreement with conclusions drawn from theoretical considerations.

36. Kondrasheva, L. D., and I. V. Podmoshenskiy. Atom concentrations in an arc plasma as determined by the pulse-absorption method. Optika i spektroskopiya, v. 9, no. 3, 1960, 281-287.

A plasma is investigated whose dc arc is burning in air between vertically mounted metal electrodes. Atom concentration determinations are made by observing the spectra of Cr, Mn, and Fe at wavelengths ranging from 2000 to 5000 Å and evaluating the corresponding arc diameters, lower energy levels, transitions, and intensity ratios. Direct atom concentration determinations are made by measuring the integral

absorption lines excited in a 2-amp arc. The pulse method permits very rapid determinations of plasma absorption spectra for temperatures up to 6000°K. It was ascertained that the volume occupied by the excited atoms situated on a 3-ev energy level is 30% that occupied by the normal atoms. Plasma composition in a dc arc between metal electrodes was found to exhibit considerable variation.

37. Konovalov, Yu. N., V. V. Magidson. Electron concentration and temperature in an output jet of a water-stabilized plasmatron. Zhurnal tekhnicheskoy fiziki, v. 32, no. 4, 1962, 450-456.

Electron concentrations and temperatures in an output jet are investigated by studying the contours of $H\beta$ and $H\alpha$ spectral lines. The Griem-Kolb-Shen contour theory is found correct. The plasmatron apparatus used in the experiment is capable of generating a plasma jet having an electron concentration of $1.7 \cdot 10^{16}$ to $15 \cdot 10^{16}$ at temperatures ranging from 1000 to 15,000°K.

38. Korolev, F. A., B. A. Kozlov, and A. I. Odintsov. Contour study of cadmium red line with the use of an atomic beam. Optika i spektroskopiya, v. 7, no. 6, 1959, 721-724.

The 6438-Å line is investigated by utilizing a Fabry-Perot interferometer, a spectrograph, and an atomic beam. A comparison of analytical and experimental data indicates that isotopic shifts are very nearly $3 \cdot 10^{-3} \text{ cm}^{-1}$ for a red cadmium line of even-isotope components. Satisfactory structure resolution of the natural line is considered practically impossible.

39. Korolev, F. A., and Yu. K. Kvaratskheli. Plasmatron as a light source for spectroscopic investigations. Optika i spektroskopiya, v. 10, no. 3, 1961, 398-402.

For the purpose of investigating spectrum excitation conditions in a plasma jet of a gas plasmatron, an arc discharge is made to burn in argon at pressures ranging from 0.3 to 5.0 atm. It is shown that temperatures in a jet plasma containing argon exceed 10,000°K and that a plasmatron is an efficient light source for spectral analysis of samples possessing poor vaporization characteristics.

40. Korostyleva, L. A., and G. A. Striganova. Isotopic shifts in uranium spectrum. *Optika i spektroskopiya*, v. 7, no. 2, 1959, 137-140.

A Fabry-Perot interferometer, a glass spectrograph, and a discharge tube with an aluminum cathode serving as a light source are employed. The line shifts are measured in the 4000 to 6000-Å region in an argon atmosphere at 1.5 mm Hg. A table is provided which shows forty spectral lines with positive shifts and six with negative shifts.

41. Kristesku, G. D., and M. Dzhurdzha. Results of spectrochemical analysis with a combined electric discharge as the light source. *Optika i spektroskopiya*, v. 11, no. 3, 1961, 424-426.

The combined discharge provides the desired excitation energy, corresponding to the temperature of an hf torch-electric-arc system. Moreover, the combined discharge, as a light source, can be utilized to form both the line and band spectra.

42. Leskov, L. V., and L. P. Vasil'yeva. Method of measuring temperature from band spectra of molecules. IN: *Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya*, v. 22, no. 6, 1958, 696-701.

The investigation is devoted to the question of accuracy in evaluating the probability of electron-oscillation transitions and in measuring temperature, and also deals with molecular-band reabsorption and determination of the concentration of CN and CuO molecules in an arc gas. Analytical formulas developed by Franck and Condon, Sobolev, and others, as well as experimental data of other authors for these molecules, are utilized. It is shown that intensity distortions caused by reabsorption prohibit temperature measurements from molecular bands and that gas arcs containing 10% of carbon derivatives are free of CN reabsorption bands.

43. Levikov, S. I., and L. P. Shishatskaya. Comparison of spectral intensities of hydrogen and deuterium radiations. *Optika i spektroskopiya*, v. 11, no. 5, 1961, 689-691.

The intensities of three continuous-band spectral lines of the Balmer series have been investigated by using an electric arc discharge. The deuterium and hydrogen pressures were 5 and 3.5 to 4.0 mm Hg,

respectively. The data show that lamps with windows of uv-transmitting glass, fused quartz, or fused sapphire should be filled with deuterium, and that lamps with windows of fluorite or lithium fluoride should be filled with common hydrogen.

44. Lochte-Holtgreven, W. Radiation from a negative hydrogen ion. IN: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 22, no. 11, 1958, 1297-1301.

Continuous spectra are evaluated on the basis of 1) data from Western studies on arc and spark discharges in hydrogen at 1 to 500 atm and 2) a shock-wave experiment conducted by the author with a mixture of Kr and H₂. The data of this experiment, plotted as Kr, H, and H⁻ spectral intensity versus temperature and wavelength, show that 1) the continuous H⁻ spectrum can be detected in light from various sources; 2) a spectrum of different origin is superposed on the H⁻ spectrum depending on whether the discharge is of the arc or spark type; and 3) shock waves create an almost pure H⁻ spectrum of high intensity. The author is with the Institute of Experimental Physics of Kiel University (West Germany). There is no indication that his article was also published in a Western source.

45. Mak, A. A. Channel temperature of a spark discharge in air. Optika i spektroskopiya, v. 8, no. 2, 1960, 278-279.

Changes in temperature, investigated as a function of current increase, are evaluated from the intensity ratios of 5535, 5495, and 5045-Å N II spectral lines at low velocities and from the brightness of a spark channel at high current-increase rates. Channel temperatures are shown to be independent of this rate.

46. Mandel'shtam, S. L., and M. A. Mazing. Broadening and shift of spectral lines in a gas-discharge plasma. IN: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 23, no. 8, 1959, 1017-1020.

Broadening and shifts of Ar II spectral lines are investigated in spark-discharge channels, the spark discharge having been excited in an argon atmosphere under normal pressure. The experiments support the nonstationary theory, as compared with the stationary Weisskopf-Lindholm theory.

47. Marshak, I. S. Pulse light source of repeated action based on electric explosions of wires. *Optika i spektroskopiya*, v. 10, no. 6, 1961, 801-804.

Experiments indicate that a tungsten spiral is the most suitable material.

48. Matora, I. M. Slow electron scattering by helium atoms with excitation of the 2^3S and 2^1S levels. *Optika i spektroskopiya*, v. 9, no. 6, 1960, 707-712.

Drukarev's method of integral equations is utilized in evaluating electron scattering from atoms having two optical electrons, such as helium. The Schrödinger approximate wave function equations, constructed after Fok, are set and solved for the S electron scatterings. The magnitudes computed are plotted as the transverse cross sections of elastic scattering versus energy. The calculated function of the excited 2^1S level shows two maxima, located at intervals of 0.2 and 7.0 eV from the excitation threshold. This result is in close agreement with experimental data of Frish and Zapesochnyy (1954) but substantially exceeds that of Maier-Liebnitz (1935).

49. Mitsuk, V. Ye. Application of the Stark effect in an alternating field for the measurement of electric fields in a uhf discharge. *Zhurnal tekhnicheskoy fiziki*, v. 28, no. 6, 1958, 1316-1325.

A hydrogen plasma discharge ($\lambda = 3.2$ cm) is investigated. Pertinent analytical formulas are stated, and the H_{β} line structure is theoretically evaluated. A detailed description of the apparatus and the technique employed is given. The data show that 1) the use of the Stark effect in an alternating field is justified under uhf conditions, and 2) the relationship between the contour-line half-widths and the electric-field amplitudes exhibits linear characteristics.

50. Mitsuk, V. Ye., M. D. Koz'minykh, and I. V. Talalayeva. Electric field measurements in uhf plasma. IN: *Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya*, v. 23, no. 8, 1959, 1031-1035.

The present study is based on 1) the work of Blokhintsev (1933), who, in developing the quantum-mechanical theory of the Stark effect for a

hydrogen atom in an alternating field, indicated that considerable differences exist in the effect in stationary and alternating fields; and 2) experiments performed by Mitsuk in 1958. The Stark effect in $H\beta$ spectral lines is investigated for both types of field; field amplitudes are evaluated by measuring such parameters as wave conductivity, wave-guide dimensions, dielectric and magnetic constants, and frequency; and electric field intensities are measured and plotted against uhf pulse discharges.

51. Nagibina, I. M. Determination from spectral-line widths of atom concentrations in an ac-arc-discharge plasma. *Optika i spektroskopiya*, v. 4, no. 4, 1958, 430-437.

Absolute concentrations of neutral atoms of Cd, Fe, Mn, and ions of Ca in discharge clouds are investigated experimentally on the basis of analytical formulas, derived from a theory suggested by Cowan and Dicke (1948), which present intensity distribution as a function of spectral-line contour. The experimental apparatus comprises a Fabry-Perot interferometer, a spectrograph, a generator, and a photographic arrangement; the arc is maintained between two carbon electrodes. The method is found effective when the absence of self-reversal is coupled with broadening of the spectral lines and can be used to determine the oscillator strength of lower state lines. Working concentrations in the discharge plasma vary from 10^{12} to 10^{13} /cm³, except for the 3261-A Cd I line. The magnitude of the concentrations depends on the type of spectral line utilized in the measurement. A linear dependence is established between line width and absolute concentration in a cloud source, which is characteristic for the yield of a substance found in the form of a thin coating on the electrode.

52. Nagibina, I. M. Determination of relative oscillator strengths in an arc discharge from spectral-line widths. *IN: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya*, v. 22, no. 6, 1958, 681-682.

Concentrations of atoms and ions in an ac-arc discharge and relative oscillator strength are investigated in a concentration region where broadening of spectral lines takes place without self-reversal. A linear relationship between the line widths of Fe I, Mg I, Mn II, and Ca II and ion and atom concentrations in an arc discharge

is discovered experimentally and combined with theoretical curves based on the theory of Cowan and Dicke. It is found that measurements of spectral line broadening, at the moment when it becomes perceptible, are sufficient to determine the strengths.

53. Nikonova, Ye. I., and V. K. Frokof'yev. Neutral-atom distribution in the plasma of a dc arc. *Optika i spektroskopiya*, v. 6, no. 2, 1959, 253-254.

The anomalous dispersion method is employed to analyze the distribution of neutral sodium atoms over arc-discharge cross sections heated along a channel axis. The maximum concentration of sodium atoms, found 1.5 mm from the discharge axis, is $1.4 \cdot 10^{16}/\text{cm}^3$; the maximum concentration of atoms in the middle cross section is $0.5 \cdot 10^{16}/\text{cm}^3$.

54. Odintsov, A. I. Light source with an atomic beam of high intensity. *Optika i spektroskopiya*, v. 6, no. 3, 1959, 398-404.

Cadmium atom beams with electron excitation glow are investigated by means of an electron gun. The method is found to be effective for production of a high-intensity glow and analysis of weak spectral lines.

55. Odintsov, A. I. Hyperfine structure and isotopic shift in the Tl I spectrum. *Optika i spektroskopiya*, v. 9, no. 2, 1960, 142-146.

A Fabry-Pérot interferometer and an atomic beam with electron-excited radiation are utilized. Thallium emission at wavelengths of 5110, 5350, 5528, 5584, 6550, and 6714 Å are investigated, and the data are given in tabular form as energy levels, isotopic shifts, and hyperfine splitting versus wavelength. The results obtained show the information given by Schuler and Keyston (1931) to be generally correct. Hyperfine splitting of the energy levels is found to be somewhat different for the Tl^{203} and Tl^{205} isotopes. The lower energy levels of Tl I exhibit hyperfine-structure anomalies.

56. Odintsov, V. I. Atomic beam as a light source for gas-spectrum investigations. *Optika i spektroskopiya*, v. 10, no. 3, 1961, 403-409.

An apparatus utilizing an arc atomic beam to obtain the spectral lines of elements is described. An electron gun is used to excite the atoms of a helium atom beam. A discharge tube with a hollow cathode is also utilized as a source of light.

57. Ostrovskiy, Yu. I., and N. F. Penkin. Measurements of f -values for barium spectral lines. *Optika i spektroskopiya*, v. 9, no. 6, 1960, 703-706.

The f -values of 65 Ba I spectral lines with wavelengths ranging from 3889 to 7911 Å are measured. A barium vapor is produced in a high-temperature oven containing an interferometer, and the spectra are photographed at temperatures ranging from 2300 to 3040°K. Relative energy-level populations are evaluated by using the Boltzmann formula. The oscillator strength ratios for the 5536 and 7911-Å wavelengths are 164 ± 5 , which compares favorably with the 146 and 169 determined by Prokof'yev and by King and Van Wiese, respectively.

58. Ostrovskiy, Yu. I., and N. F. Penkin. Measurement of absolute magnitudes of oscillator strengths of Ba, Ca, and Sr ion resonance lines. *Optika i spektroskopiya*, v. 10, no. 1, 1961, 8-14.

The resonance doublet lines of Ca II, Sr II, and Ba II are investigated by utilizing the anomalous dispersion method and the Sakb formula, the latter is found to produce results in agreement with the experimental results. The mean f values of the three doublets are almost constant over a broad range of oven temperatures.

59. Ostrovskiy, Yu. I., and N. F. Penkin. Oscillator strengths of calcium spectral lines. *Optika i spektroskopiya*, v. 10, no. 4, 1961, 429-435.

Data from a study conducted according to the anomalous dispersion method show that 1) the f -values of the principal series of calcium singlets exhibit nonmonotonic changes with variations in the principal quantum number; 2) the data obtained in the

experiments do not deviate excessively from those of Schuttevear (1943) and Allen (1957); and 3) the relative f-values, semiempirically computed, agree well with the measurements.

60. Ostrovskiy, Yu. I., and N. P. Penkin. Measurement of absolute values of oscillator strengths in atomic spectra. I. Sodium and II. Resonance lines of group-II atoms. *Optika i spektroskopiya*, v. 11, nos. 1 and 5, 1961, 3-11 and 565-570.

I. A method is described which is based on simultaneous measurements of absorption and dispersion and on evaluations of the wings of the absorption lines.

II. Ca I, Sr I, and Ba I lines are studied. Data pertaining to the $^3S_0-^3P_1^0$ resonance lines are compared with values obtained from analytical expressions and from data collected by other investigators.

61. Pavlichenko, O. S., and L. A. Dushin. Spectroscopic study of plasma in Phillips' pulse discharge. *Optika i spektroskopiya*, v. 12, no. 5, 1962, 541-545.

Spectral line intensities of hydrogen H_α under the influence of magnetic fields have been investigated in pulse discharges with a cold cathode. Spectral-line-intensity oscillograms were observed for a magnetic field of $2.7 \cdot 10^{-3}$ sec and for pressures ranging from $5 \cdot 10^{-3}$ to $150 \cdot 10^{-3}$ mm Hg. They indicate the presence of two maxima, brought about by changes in electron temperature at $\approx 40,000$ and 1000° K.

62. Pedos, F. Z., and N. S. Sventitskiy. Spectrum excitation by low-voltage pulse discharges in a vacuum. *Optika i spektroskopiya*, v. 4, no. 3, 1958, 407-409; and v. 5, no. 6, 1958, 706-707.

The first article treats electric discharges for excitation of metallic electrodes. In this case, copper electrodes are introduced into a vacuum container, with ignition taking place at pressures of 10^{-4} to 10^{-5} mm Hg. Bursts in vacuum prove to be similar to those in air, and it is concluded that the intensity and shape of metal spectral lines in vacuum can be used as concentration indicators in the analysis of steel and other metallic compounds.

The second article takes up the spectral characteristics of Fe, Cu, C, Al, W, and other elements. The probability that low-voltage pulse discharges can be used as a source of light in the vacuum spectrum region is indicated.

63. Podmoshenskiy, I. V., and V. M. Shelemina. Determination of analytical spectral-line absorption in arc and spark [discharges]. *Optika i spektroskopiya*, v. 6, no. 6, 1959, 813-815.

Spectral lines of Ni, Cr, Si, and Mn are investigated in a dc arc and in a high-voltage spark discharge. The data are plotted and analyzed.

64. Pollyul', Yu. P. The role of diffusion in the intake process of a substance into a discharge cloud. *Optika i spektroskopiya*, v. 13, no. 2, 1962, 270-272.

The intake of metal electrode material into the discharge cloud of an ac arc and the effects of the vaporization process are investigated by alloying iron with one of the following elements in a 1:1 atomic ratio: Al, Co, Cr, Cu, Mn, Mo, Nb, Ni, Si, and Ti. In addition, iron electrodes were alloyed with very small amounts (0.4%) of Si, Mn, Cr, and Ni. The data indicate that there is a definite and regular relationship between the intensity of the iron spectral line and the partial vapor pressure of an impurity element. The spectral lines of Si, Mn, Cr, and Ni used as 0.4% impurities obey the same relationship, although on a different scale.

65. Prokof'ev, V. K., D. B. Gurevich, I. M. Belousova, and Yu. A. Snigirev. Time required for establishment of thermodynamic equilibrium in an arc discharge plasma. *Optika i spektroskopiya*, v. 7, no. 1, 1959, 14-20.

Atmospheric pressure is used. The temperatures of excitation, oscillation, and rotation are measured for the atoms and molecules in the plasma, and the Fe I atomic spectral lines (5269.5 and 4325.76 Å) are utilized for measuring excitation temperatures. The experiments give a time of 20 to 25 μ for an arc burning in air.

66. Prokof'yev, V. K., I. M. Nagibina, and G. P. Petrova. Determination of the absolute values of oscillator strengths from spectral-line widths. *Optika i spektroskopiya*, v. 8, no. 3, 1960, 376-381.

An analytical and experimental study is made. The first part of the latter consists in measuring the concentrations of Ca and Mg ions and atoms in an arc-discharge cloud by using carbon and copper plate electrodes. The second consists in evaluating the oscillator strength for a 2863.33-Å resonance line of tin, with manganese selected as a comparison element. The method affords an easy means of determining oscillator strengths with errors not exceeding 20%.

67. Raykhsbaum, Ya. D., and V. D. Malykh. Spectroscopic study of atom diffusion in an electric arc. *Optika i spektroskopiya*, v. 9, no. 4, 1960, 425-427.

A pulse method is utilized for the introduction of gas into an arc discharge, and the spectral line intensities are measured. Effective diffusion coefficients and the mean lifetimes of Li, Na, Ca, Zn, Ag, Bi, and Tl atoms in an arc discharge are evaluated and given in a table and graph. The data show that the line-intensity decrease obeys the exponential law and that an increase in the magnitude of arc current leads to an increase in the mean lifetimes of the elements. This increase is proportional to I^k , where $k = 1.0$ to 1.3 .

68. Raykhsbaum, Ya. D., and V. D. Malykh. A possible cause of the carrier effect in spectral analysis. *Optika i spektroskopiya*, v. 10, no. 4, 1961, 524-527.

The influence of carriers on the intensities of impurity spectral lines is investigated in a dc arc. The carriers used are AgCl, LiF, LiCl, NaCl, NaF, LiI, NaBr, Na₂CO₃, and Li₂CO₃, are introduced separately into an arc channel, and the average changes of the atom lifetimes in the zone of excitation are recorded from lithium, thallium, zinc, and mercury atoms. Carrier action is found to depend on the ionization potentials of the impurity atoms.

69. Razumovskaya, L. P., and O. P. Bochkova. Optical and electrical properties of weak and strong hf discharges in neon. *Optika i spektroskopiya*, v. 9, no. 2, 1960, 271-273.

A 6-Mc ac current is employed. A discharge tube 15 cm in length is maintained at pure-neon pressures of 0.2 to 0.3 mm Hg. Electron temperatures and electron concentrations are measured by the two-probe method, and optical properties of two discharge types in neon are studied. The experiments show that 1) the electron temperature magnitudes remain constant for weak and strong discharges and for 700 to 1300-v voltage differences between the external electrodes, and 2) hf weak discharge is well adapted for achieving sensitivity increases in gas concentration analysis.

70. Rovinskiy, R. Ye., and G. P. Razumtseva. Degree of transparency of a discharge in xenon at superhigh pressures. *Optika i spektroskopiya*, v. 7, no. 6, 1959, 725-728.

Transparency magnitudes, investigated as a function of discharge power per unit length in the visible spectrum, are transformed into average absorption coefficients by employing a simple analytical expression. The experimental apparatus comprises two spherical xenon lamps at working pressures of 20 to 25 atm and an appropriate optical system. Graphs of absorption coefficient versus discharge power indicate that the absorption rate in the column increases rapidly at low power, the rate of growth diminishing at powers > 2.5 kw.

71. Rudnevskiy, N. K., and Yu. S. Kalinin. The nature of the effect of "third" elements on spectral-line intensities in the analysis of some copper-base alloys. IN: *Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya*, v. 26, no. 7, 1962, 846-848.

The alloys are introduced into the gas of an arc, and spectrum excitation changes are studied under the assumption that the excitation changes are a function of Fe and P⁺ concentrations in Cu-Ni alloys. The data show that the intensities of iron spectral lines depend on the rate at which the alloy is fed into the arc, the concentration of iron in the alloy, and the temperature and degree of ionization.

72. Safronov, B. G., P. V. Mitin, A. A. Kalmykov, and V. G. Konov-alov. Investigation of hf oscillations of the Luce vacuum arc plasma. Zhurnal tekhnicheskoy fiziki, v. 31, no. 10, 1961, 1248-1252.

The Luce arc in this case is a carbon arc burning along a magnetic field at pressures ranging from 10^{-6} to 10^{-8} mm Hg. An oscillograph is used for measuring hf oscillations and a spectrograph for arc-spectrum investigations. The spectral data show the presence of C^+ , C^{++} , and C^{+++} ions and the absence of the spectral line of neutral carbon.

73. Samson, A. M. Resonance radiation of finite volumes. Optika i spektroskopiya, v. 5, no. 5, 1958, 500-510.

Integral-differential equations are derived which permit the evaluation of stimulated radiation and thermal background in addition to resonance radiation. The equations are solved by the method of successive approximations and are expressed as a distribution of excited particles under stationary conditions. The solutions of the equations indicate that, in general, resonance radiation of finite volumes requires the evaluation of higher-order radiation.

74. Sherstkov, Yu. A. Applicability of the Cowan and Dicke function to a dc arc. Optika i spektroskopiya, v. 6, no. 6, 1959, 817-818.

Conclusions drawn by the authors from the Cowan-Dicke model are compared analytically with observational data obtained by the photoelectric and photographic methods. Intensity distributions in the central-arc cross sections are observed for the resonance lines of Ba and Sr atoms and as a means of evaluating radial temperature distribution for the Cu I line ($\lambda = 5105$ and 5218 \AA). The true line intensities, radially distributed, are evaluated by using an experimental method based on Hörmann's. It was determined that the temperature on the arc axis is 5600°K and decreases slowly toward the periphery, reaching 3700°K at a distance of 3.6 mm. The relative excitation function and the absorption parameters are found by utilizing the graphical integration method proposed by Cowan and Dicke. It is concluded that the Cowan-Dicke function can be employed in evaluating line profiles emitted by dc arcs. Resonance lines of atoms possessing low ionization potential, however, are subject to an error of 20%.

75. Shreyder, Ye. Ya. Intensity measurements in the Balmer series and concentration determination of excited atoms in a discharge. *Optika i spektroskopiya*, v. 6, no. 3, 1959, 279-283.

H_{α} , H_{β} , H_{γ} , and H_{δ} lines are measured, and a discharge tube at pressures ranging from 0.25 to 1.5 mm Hg and currents from 70 to 250 ma is employed in concentration determination. The data, given in tables and graphs, show that 1) the reabsorption magnitudes permit the determination of excited atom concentrations, 2) knowledge of gas pressure in a discharge tube and of excited atom concentrations permits temperature evaluations by utilization of the Boltzmann equation; and 3) the line intensities computed from the Boltzmann equation do not differ significantly from those evaluated from observational data.

76. Shvangiradze P. P. Anomalous intensity variations of samarium spectral lines in a dc arc. *Optika i spektroskopiya*, v. 5, no. 1, 1958, 88-90.

Samples of samarium oxides mixed with graphite powder are introduced into a dc arc between two carbon electrodes at a current of 5 amp. A spectrograph and an appropriate camera are utilized in the experiment. The following conclusions are drawn. 1) The use of samarium as a standard element in the spectral analysis of rare-earth elements decreases the accuracy of the analysis. 2) Selective evaporation of samarium tends to increase the sensitivity of mixture determination in the samarium electrodes. 3) High arc-current magnitudes increase the determination sensitivities of mixtures in samarium, whereas low magnitudes increase the determination sensitivities of samarium in other rare-earth elements.

77. Shvangiradze, P. P., K. A. Gerasimov, and E. Ya. Chikhladze. Temperature and thermal equilibrium in an arc burning in inert gases. *Optika i spektroskopiya*, v. 13, no. 1, 1962, 25-31.

The spectrum of a dc arc burning between pure graphite electrodes is investigated in N, Ar, He, Ne, and Kr atmospheres at a working pressure of 600 mm Hg. The spectra of carbon and iron are excited concurrently in the burning arc. The temperatures are evaluated by measuring the relative intensities of carbon and iron spectral lines and the Doppler broadening of the spectral line of

iron. Data derived from the experiments indicate that introduction of iron into the electrodes does not change the basic characteristics of the spectrum obtained between pure electrodes. The temperature of the central portion of the arc is estimated as $(8 \text{ to } 9.7) \cdot 10^3 \text{ }^\circ\text{K}$.

78. Shvangiradze, P. P., K. A. Oganezov, and B. Ya. Chikhladze. DC arcs at various pressures of argon and air. *Optika i spektroskopiya*, v. 13, no. 4, 1962, 613-615.

Emission characteristics and arc temperatures are investigated as a function of pressure changes in atmospheres of the inert gases He, Ar, and Ne and of C II and C III. The arc burns between carbon electrodes 10 mm apart, and the temperatures are evaluated by measuring the line intensities in the iron spectrum. No carbon ion spectral line is observed in an arc burning in air at pressures ≤ 1 atm. The excitation mechanism of carbon ions does not obey the Boltzmann law. Spectral lines of argon atoms are observed at all pressures under investigation ($\sim 10^1$ to 10^4 mm Hg).

79. Shukhtin, A. M. Determination of gas density and electron concentration in a discharge by the interferometer method. *Optika i spektroskopiya*, v. 7, no. 6, 1959, 838-839.

Changes in gas density in a pulse discharge tube are investigated in an atmosphere of argon by utilizing an interferometer and a spectrograph and by measuring changes in the refraction index. In some discharge phases the gas-density changes are large, and at the initial argon pressure of 6 mm Hg may correspond to an almost complete gas withdrawal from the area located along the tube axis.

80. Sobolev, N. N., A. V. Potapov, V. F. Kitayeva, F. S. Fayzullov, V. N. Alyamovskiy, Ye. T. Antropov, and I. L. Isayev. Spectroscopic state investigation of a gas behind a shock wave. I. *Optika i spektroskopiya*, v. 6, no. 3, 1959, 284-296.

The relative intensities of Li and Na spectral lines are utilized for temperature evaluation. Many difficulties were found in attempting to employ this method. It was discovered that the method based on the reversal of spectral lines is better adapted for temperature evaluations at 1500 to 5000 $^\circ\text{K}$. For higher temperatures the relative intensity method can be utilized.

81. Startsev, G. P., and M. S. Frish. Temperature measurements of an arc between iron electrodes from self-reversed spectral lines. IN: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya, v. 26, no. 7, 1962, 927-929.

A method developed by Bartels (1950, 1958) is employed. The measurements, conducted at voltages of 350 and 110 v and currents of 2.2 and 5.0 amp, respectively, give 4560 ± 200 and $5070 \pm 200^\circ\text{K}$ as the maximum axial temperatures. They give a strong indication that under atmospheric pressure the local temperature magnitudes and excited-level populations in an electric arc obey the Boltzmann distribution law.

82. Sukhodrev, N. K. and S. L. Mandel'shtam. Electrode vapor temperature in a spark discharge. Optika i spektroskopiya, v. 6, no. 6, 1959, 723-728.

Measurements of the spectral lines of doubly and triply ionized atoms of Al, Ag, Ba, Cu, Ga, Pb, Sn, Mg, Si, and Zn show that vapor temperatures range from 30,000 to 35,000°K.

83. Tskhay, N. S., and S. L. Mandel'shtam. Influence on spectral line intensities in a flame spectrum. Optika i spektroskopiya, v. 7, no. 2, 1959, 141-151.

Free atom concentrations and various factors affecting their excitation are studied by using an acetylene lamp, plane mirrors, a spectrograph, and an appropriate optical system. Na, K, Mg, Li, Sr, Ca, and Ba are introduced into the flame separately or in various combinations. Careful attention is given to changes in absolute atom concentration in the flame zone when changes occur in the composition of the compounds or when new elements are added. The anomalous dispersion method is utilized for measuring atom concentration. It is shown that spectral-line intensities are influenced by changes in atom concentrations and excitation conditions, the latter effect as a result of flame-temperature changes.

84. Turkin, Yu. I. Intensity anomalies in the hyperfine-structure components of thallium resonance lines. *Optika i spektroskopiya*, v. 7, no. 1, 1959, 10-13.

A parallel beam of light from a continuous spectrum source is used to produce radiation in passing through a discharge tube filled with thallium vapors at pressures of $3 \cdot 10^{-2}$ and $5 \cdot 10^6$ mm Hg and temperatures of 630 and 520°C , respectively. Data on the 2760.8 and 3775.7-Å lines show that the thermodynamic equilibria at lower sublevels are disturbed at an inert-gas discharge-tube pressure of 0.1 mm Hg. At higher pressures, e.g., 0.8 mm Hg, nonsimultaneous component reversal was not observed.

85. Turkin, Yu. I., and M. P. Chayka. Anomalous ratio of the hyperfine-structure-component intensities of indium spectral lines. *Optika i spektroskopiya*, v. 11, no. 5, 1961, 695.

A hollow cathode filled with liquid air is utilized, through which currents of 10 to 190 ma are passed.

86. Vanyukov, M. P., and A. A. Mak. Generation of high temperatures by a spark discharge. IN: *Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya*, v. 23, no. 8, 1959, 962-964.

Channel temperatures in spark discharges have been investigated by measuring spectral-line intensities of the channel at the centers of strongly broadened lines of Ar, Ne, and Xe ionized atoms. Temperatures evaluated by using the linear and continuous methods do not differ perceptibly, and there are no large temperature gradients in the channel cross sections.

87. Vanyukov, M. P., A. A. Mak, and V. P. Muratov. Time-dependent emission spectra of a spark discharge in inert gases. *Optika i spektroskopiya*, v. 6, no. 1, 1959, 17-23.

Spectral densities of channel brightness in pulse discharges are investigated in an atmosphere of heavy inert gases (Ar, Kr, and Xe) at high pressures and currents. Spectral lines in the 2500 to 5500-Å range are plotted as a function of time. These spectra are taken to indicate the presence of relatively high concentrations of doubly ionized atoms in the discharge channel. The spectral densities of light energies are said to demonstrate their weak dependence on wavelength.

88. Vanyukov, M. P., A. A. Mak and V. P. Muratov. Spark-discharge emission in helium. *Optika i spektroskopiya*, v. 8, no. 4, 1960, 439-445.

A spark discharge is generated in a pulse lamp filled with helium at pressures ranging from 2.5 to 12.0 atm. The channel emission spectrum is recorded in the 2500 to 5500-Å band and plotted against time. Electron concentrations in the spark channel plasmas are evaluated by measuring the half-widths and shifts of the 5016 and 3889-Å lines and by utilizing the Weisskopf-Lindholm theory with the Vaynshteyn-Sobell'man corrections. The data show that 1) spark-discharge emission in helium for a 2.5-atm pressure is characterized, in its initial stage, by a strong continuous background in the waveband studied, helium arc lines appearing later; and 2) the spark and arc emission lines manifest a strong broadening and are displaced on account of the Stark effect.

89. Vanyukov, M. P., V. P. Muratov, and I. A. Mukhitdinova. Time-resolved emission spectra of spark discharges in gases in the 5000 to 10,000 Å region. I. Nitrogen and air; II. Helium, neon, krypton, and xenon. *Optika i spektroskopiya*, v. 10, no. 4, 1964, 561-563; and v. 11, no. 3, 1961, 312-318.

I. The density of light in the infrared region is investigated at a pressure of 1 atm. The spectra of nitrogen and air are found to be practically identical.

II. A pulse lamp is employed. It is shown that 1) discharge brightness increases with the atomic number of the gas; 2) intense ionization occurs in the first moments of discharge; and 3) the line intensities of some of the inert gases increase with pressure.

90. Vashman, A. P., L. V. Il'ina, and N. A. Teterina. UHF source of spectrum excitation in gas mixtures. *Optika i spektroskopiya*, v. 6, no. 2, 1959, 260-262.

Argon-helium mixtures are investigated spectroscopically by utilizing a 3000-Mc magnetron and discharge tube pressures ranging from 0.3 to 20 mm Hg. Changes in the spectral-line intensities of Ar and He are given as a function of their concentrations in the mixtures.

91. Vasil'yev, V. I., V. S. Komal'kov, Yu. V. Skvortsov, and S. S. Tserevitinov. Stable dynamic current pinch. Zhurnal tekhnicheskoy fiziki, v. 30, no. 7, 1960, 756-768.

The formation and development of a current pinch is investigated in a plasma jet moving through argon, deuterium, and hydrogen at working gas pressures ranging from 0.01 to 10 mm Hg. Plasma motion is investigated by using spectral and magnetic observations. The data show that the current pinch is stable during the discharge half-period and that the magnetic field magnitudes are very small outside the plasma jet areas.

92. Vasil'yev, V. I., M. S. Levchuk, and I. S. Marshak. Flash duration of tubular pulse lamps. Optika i spektroskopiya, v. 11, no. 1, 1961, 118-122.

Ar, Kr, and Xe are utilized in plotting the duration as a function of gas pressure, discharge-tube dimensions, working voltage, capacitance, and other tube characteristics.

93. Vaynshteyn, L. A. Excitation of atoms and ions by electron impacts. Optika i spektroskopiya, v. 11, no. 3, 1961, 301-307.

Effective cross sections are evaluated analytically for many energy-level transitions of C, Na, He, and H atoms and ions by utilizing the Born approximation and the wave-distortion method. An approximate relationship between the oscillator strength and the maximum cross-section magnitude is established.

94. Vernyy, Ye. A. and V. N. Yegorov. Isotopic effect in the spectrum of $^{232}\text{Th}^{229}$. Optika i spektroskopiya, v. 6, no. 2, 1959, 262-264, and v. 9, no. 6, 1960, 692-702.

In the first article the thorium spectrum is excited in an arc and an atmosphere of carbon dioxide. The spectra are recorded with the use of a diffraction spectrograph. The presence of isotopic shifts in the spectral region between 2600 and 4400 Å is indicated.

In the second article the same experimental conditions are employed, and tables are included showing line and level shifts in Th I, Th II, U I, and U II. The odd-even effect in the thorium spectrum and the nuclear deformations of thorium are investigated analytically, and the $^{232}\text{Th}^{229}$ quadrupole moment, which is caused by a nuclear deformation, is evaluated.

95. Volkova, L. M. Effective excitation cross sections of potassium spectral lines. *Optika i spektroskopiya*, v. 6, no. 3, 1959, 273-278.

Arc and spark discharges are employed at a working temperature of 127.5°C and a pressure of $1.3 \cdot 10^{-3}$ mm Hg. Plots of the cross sections versus electron-excitation energies are given for both arc and spark spectral lines.

96. Volkova, L. M. Effective excitation cross sections of certain spectral lines of sodium. *Optika i spektroskopiya*, v. 11, no. 6, 1961, 775-777.

The intensities of ten lines in the sodium spectrum are compared with those of a tungsten lamp. Measurements are made at 455 and 475°K and a working pressure of $5 \cdot 10^{-6}$ mm Hg. An electron gun supplies a beam of electrons with energies of 4 to 100 eV. The results of observations for certain transition energy levels are given in tabular form.

97. Volkova, L. M., and P. M. Devyatov. Effective excitation cross sections of some argon spectral lines. *Optika i spektroskopiya*, v. 7, no. 6, 1959, 819-820.

The electron-velocity dependence of the cross sections is investigated in the 7724 to 8424-\AA region and a pressure of $4.68 \cdot 10^{-6}$ mm Hg. The cross sections are given in a table and are plotted against exciting-electron energies.

98. Vul'fson, K. S., and F. A. Charnaya. Channel-diameter measurements of high-pressure pulse discharges in various spectral regions. *Optika i spektroskopiya*, v. 11, no. 4, 1961, 549-551.

Channel diameters are measured in argon, krypton, and xenon lamps for short and long-wave emissions by utilizing an optical system. The discharge channel of the pulse lamp is projected on the aperture plane of a monochromator, and time scanning is accomplished with the use of a revolving mirror-like objective. Channel measurements are determined by separating the scanning photographs at intervals of 0.1 sec. It is established that the channel-diameter magnitudes are larger for long-wave than for short-wave emissions.

99. Yakhontova, V. Ye., and M. I. Klots-Dobinskiy. Dependence of the intensity of some helium lines on pressure. *Optika i spektroskopiya*, v. 7, no. 4, 1959, 446-453.

An analytical and experimental investigation is conducted for the 5016 and 3965-Å lines by utilizing a monochromator and a discharge tube. Plots of line intensity versus pressure are non-linear. Both the experimental and theoretical curves manifest the same characteristics.

100. Yegorov, V. S., and A. M. Shukhtin. Afterglow and its relation to gas density in a neon pulse discharge. *Optika i spektroskopiya*, v. 9, no. 6, 1960, 794-796.

A discharge tube is employed. Pressures range from 1 to 4 mm Hg, and impulse durations are 16 and 200 μ sec. Theoretical considerations based on the method of anomalous dispersion and pertaining to the energy level populations are briefly stated, and charged-particle concentrations are evaluated from sample and interferometer observations. Data from the experiment reveal that the increase in excited-atom concentrations is greater after the cut-off of a short-pulse current and that the subsequent current-gas-density changes do not exceed 25% of their initial values. The investigation was conducted at a neon pressure of 1 to 4 mm Hg and current-pulse duration of 16 μ sec and 200 μ sec.

101. Yegorova, V. F., V. I. Isayenko, A. A. Mak, and A. I. Sadykova. Temperature distribution and electron concentration in a spark-discharge channel. *Zhurnal tekhnicheskoy fiziki*, v. 32, no. 3, 1962, 338-345.

Spectral-line intensities and the plasma continuum in helium and nitrogen atmospheres are utilized. Emission intensities are measured in helium and nitrogen spark discharges at pressures of 10 and 2.5 atm, respectively. The results of the measurements are given in a tabular form and as plots of temperature distribution and electron concentration versus spark-discharge channel.

102. Zakharova, V. M., and Yu. M. Kagan. Spectroscopic determination of ion velocities in a mixture of inert gases. *Optika i spektroskopiya*, v. 10, no. 4, 1961, 547-549.

The magnitudes of ion velocities and longitudinal field intensities are measured in a positive discharge column at currents of 1.2, 0.6, and 0.3 amp for Ar-Kr, Ar-Xe, Kr-Xe binary mixtures, respectively. The experimental data agree with results obtained analytically.

103. Zakharova, V. M., Yu. M. Kagan, and V. I. Perel'. Spectroscopic observation of the rotation of a positive discharge column in a magnetic field. *Optika i spektroskopiya*, v. 11, no. 6, 1961, 777-779.

The rotation of a neutral gas in a positive discharge column is investigated in a discharge tube filled with argon gas at pressures ranging from 0.5 to 2.5 mm Hg in the presence of magnetic fields of 250, 600, and 1000 oe. Interference rings are found to shift because of directional changes of the magnetic fields, and the spectral lines to widen with an increase in the magnitudes of the magnetic fields.

104. Zapesochnyy, L. I., and L. L. Shimon. Study of optical functions of sodium excitation with the photoelectric method. *Optika i spektroskopiya*, v. 13, no. 5, 1962, 624-625.

An investigation is conducted in the visible-spectrum region under conditions leading to minimum distortions of the excitation functions. Special attention is given to the study of the resonant sodium doublet. Measurements are made at pressures of $(1 \text{ to } 5) \cdot 10^{-4}$ mm Hg. The spectral lines of some doublet lines of sodium exhibit a hyperfine structure.

105. Zaydel', A. M., and Ye. P. Kisil'nyy. Spectral determination of the isotopic composition of lithium and its concentration in solutions. *Optika i spektroskopiya*, v. 10, no. 5, 1961, 570-576.

A discharge tube with a hollow cathode and a stream of helium under a pressure of 1 mm Hg are utilized to investigate the absorption of the lithium 6708-Å resonance line in a flame. Discrepancies between the experimental and analytical magnitudes do not exceed 8%. A single analysis does not require more than 3 min.

106. Zaydel', A. N., G. M. Malyshev, Ye. Ya. Shreyder, A. B. Berezin, V. A. Belyayeva, V. I. Gladushchak, V. V. Skidan, and L. V. Sokolova. Spectral investigations with an "Al'fa" installation. I. Study of spectral characteristics and ion temperature. Zhurnal tekhnicheskoy fiziki, v. 30, no. 12, 1960, 1422-1432.

Spectral lines (350 to 5000 Å) of hydrogen and various impurities, such as C, O, N, Al, F, and Si ions, are recorded and their relative intensities analytically and experimentally evaluated. The relationship of temperature and ion charge is evaluated for C, O, and N and illustrated in a graph. Some suggestions are made pertaining to the mechanism underlying the magnitudes observed.

107. Zaydel', A. N., G. M. Malyshev, Ye. I. Moskalev, Ye. A. Ptitsyna, L. V. Sokolova, and G. I. Chashchina. Spectral investigations with an "Al'fa" installation. II. Direction of ion motion. Zhurnal tekhnicheskoy fiziki, v. 30, no. 12, 1960, 1433-1436.

The data show that 1) the ions move along the discharge axis, and 2) the velocities of directional motion do not exceed 10^6 cm/sec and increase with an increase in ion charge.

108. Zaydel', A. N., G. M. Malyshev, A. B. Berezin, and G. T. Razdobarin. Spectral investigations with an "Al'fa" installation. III. Transient glow characteristics of plasma. Zhurnal tekhnicheskoy fiziki, v. 30, no. 12, 1960, 1437-1446.

Mechanical spectrum scanning and the Doppler-shift method are described. Suggestions pertaining to certain plasma characteristics are made.

109. Zaydel', A. N., G. M. Malyshev, and Ye. Ya. Shreyder. Spectroscopic methods for investigation of hot plasma. Zhurnal tekhnicheskoy fiziki, v. 31, no. 2, 1961, 129-166.

A detailed and comprehensive review, based on 119 references, is given of the theory and results achieved in the application of spectroscopic techniques to investigations of hot plasma. Hot plasma is defined as that whose basic components have temperatures of

10^6 to 10^{10} °K or higher. The article covers plasma investigations in the 10 to 7000-Å region and at pressures ranging from 10^{-6} to 10^{-2} mm Hg. It contains the following subdivisions: 1) broadening of spectral lines and ion temperature; 2) directed ion motion; 3) electron temperature; 4) electron concentration; 5) impurities; 6) energy loss; 7) transient characteristics of plasma glow; and 8) space characteristics of plasma glow.

110. Zaydel', A. N., A. M. Razumovskiy, and M. P. Chayka. Spectral analysis of lithium isotope composition. *Optika i spektroskopiya*, v. 10, no. 1, 1961, 15-18.

A method of analysis is given based on intensity measurements of resonance-doublet components by utilizing a discharge tube having a hollow cathode and containing helium at a pressure of 1.6 mm Hg. Working errors in isotope determination were found to vary from 0.15 to 0.7% at Li^6 concentrations of 40 to 90% and did not exceed 6% in small concentrations. The complete analysis does not take more than 15 min.

111. Zheyenbayev. The investigation of hf discharge with hydrodynamic compression. *Optika i spektroskopiya*, v. 9, no. 3, 1960, 288-294.

Cu and Fe spectral lines are analyzed to determine temperature characteristics. Ten Fe lines are utilized to determine transition probability by several methods, such as anomalous dispersion, total absorption, and λ/λ_0 . The dependence of discharge temperature on the ionization potential of a substance present in solution, on the concentration of a cathode element (KCl and NaCl) and on generator power is shown in graphs. It is established that an hf discharge in combination with a hydrodynamic compressive force forms a source of light having OH, O_2 , H_2 , and other molecular spectra with wavelengths of 3064 to 3350 Å (OH) and 6125 to 6750 Å (other molecules). Long exposure in the 5620 to 6121 Å region leads to the appearance of an N_2 molecular spectrum. At high generator power and compression intensity the discharge temperature can exceed 8000°K.

112. Zhiglinskiy, A. G., A. N. Zaydel', and E. A. Karklina. Investigation of a dc arc at increased pressure. *Optika i spektroskopiya*, v. 10, no. 6, 1961, 697-701.

Changes in the spectral-line intensities of lithium and copper at pressures up to 10 atm are investigated. It is concluded that 1) the substitution of carbon dioxide for air does not appreciably alter the arc emission characteristics; 2) when arc pressure is increased to 7 atm, arc temperature rises from 6000 to 6700°K; and 3) Na, Al, Cu, Zn, Fe, Sn, Sb, and N exhibit an increase in their spectral line intensities with increases in pressure.

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