From the point of view of the theoretician, the shortcomings of the proposed scheme are the fact that it is uneconomical (an extra particle R^-) and it foregoes the known deductions concerning electromagnetic interactions in SU(6), including the impressive prediction concerning the ratio of the neutron and proton magnetic moments. The advantages of the R^- scheme are connected with the intuitive concepts of the meson and baryon structure.

In constructing mesons of quarks and antiquarks, we assume that the latter attract each other, and accordingly two quarks repel each other, at least at ultrashort distances. In the scheme with the R^- boson, it is natural to assume that the quarks are attracted to R^- and repel each other. Inasmuch as three quarks in $(p)^3$ state are fully antisymmetrical in the coordinates ($\ell_z = 1$, $\ell_z = 0$, $\ell_z = -1$, $L = 0$), we obtain a natural representation of a decuplet of baryons with $J^P = 3/2^+$ and an octet of baryons with $J^P = 1/2^+$. The identical orbital wave functions of the decuplet and the octet correspond precisely to the fact that the decuplet and the octet combine into a single representation with 56 elements in SU(6). This intuitive scheme is developed in a tutorial article by the author [2].

[1] T. D. Lee, Nuovo cimento 35, no. 3 (1965)
[2] Ya. B. Zel'dovich, UFN 86, no. 6 (1965), Soviet Phys. Uspekhi 8 (1965).

---

1) If the quark mass difference is smaller than the mass of the corresponding meson ($m_\Lambda < m_{p,n} + m_K$, $m_p < m_n + m_\pi$), then the transformation proceeds via weak interaction. If $|m_p - m_n| < m_e$, then two quarks, p and n, are stable in vacuum.

2) In this case we ascribe to the quarks a lepton decay, and the correspondence between the quarks and the leptons can be established, for example, from the Kiev symmetry of $(\Lambda\mu)$, (ne), and $(p\nu)$. However, the existence of neutral currents (pe), $(n\nu)$, and $(\Lambda\nu)$ is also possible.

AMPLIFICATION OF COHERENT RADIATION USING STIMULATED RAMAN SCATTERING

B. A. Akanaev, S. A. Akhmanov, and R. V. Khokhlov
Moscow State University
Submitted 6 April 1965

We present preliminary results of an experiment on the amplification of an external signal by using stimulated Raman scattering (SRS). In the experiments performed to date [1, 6-8], in accord with theory [2-5], powerful radiation was observed at the frequency of self-exciting waves $\omega_s = \omega_0 - \Omega$, where ω_0 is the pump frequency and Ω one of the frequencies of the molecular oscillations active in the Raman scattering. However, there are no reports in the literature of the use of the SRS phenomenon for amplification of an external signal of Stokes frequency. At the same time, the problem of effective amplification of coherent radiation with wavelengths for which powerful sources are available is very timely. By using an amplifier for the Stokes component and a Raman laser, one could realize the transmission and reception of monochromatic radiation.

The difficulty in observing amplification of an external signal using the SRS effect is connected with the fact that the amplification bandwidth is quite narrow, of the order of 1 - 5 cm^{-1}, and that in order to observe reliably amplification at a given frequency it is necessary to have a narrow-band light source of frequency $\omega_s = \omega_0 - \Omega$. Such a source may be a Raman generator. If we use pump radiation from different lasers for the excitation of this generator and for the amplification of the Stokes wave, then it becomes necessary to synchronize two laser pulses with accuracy 10 nsec. This difficulty can be circumvented by using a beam from a single laser both for generation and amplification of the Stokes wave.

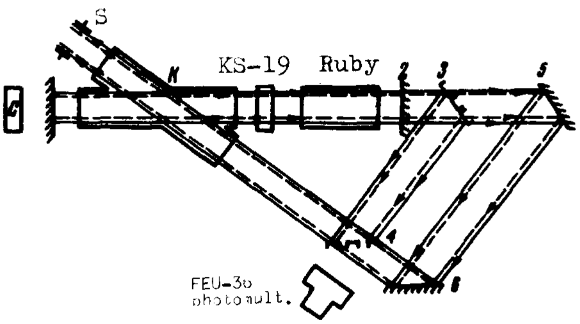

Fig. 1. Diagram of installation (C - calorimeter)

The working diagram of such a set-up is shown in Fig. 1. In this system, the same cuvette K, placed inside the cavity of a Q-modulated ruby laser, is used both for the generation of the Stokes component and for its amplification. The cuvette is made up of two glass tubes, 20 mm in diameter, fused together and crossing at an angle 20°, and half-filled with benzene.

The cavity mirrors 1 and 2 have a reflection coefficient R close to 99% at wavelengths from 6900 to 7500 Å. The beam emerging from mirror 2 contains the Stokes and Rayleigh components. After being partly reflected from the semitransparent mirrors 3 and 4 and after passing through the air space in the cuvette, this beam enters the upper part of the spectrograph slit (mirrors 3 and 4 had a reflection coefficient of approximately 40% at wavelengths from 6900 to 7500 Å). The other part of the beam passing through the mirror 3 is reflected from aluminum mirrors 5 and 6 (R = 90%), passes through a semitransparent mirror and the lower part of the cuvette K (through the benzene), and enters the upper part of the spectrograph slit S. The light is thus split into two beams, one passing through the benzene which is irradiated at the pump frequency, and the other throught the air. By comparing the ratios of the intensities of the Stokes and Rayleigh components for both beams it is possible to determine the amplification.

The Q modulation 1) was by means of a filter of KS-19 glass.

The amplification was registered with Infra 720, 750, and 760 photographic plates.

Figure 2 shows a positive photograph of four laser flashes. The last flash (4) was produced without Q modulation and with a weak pump signal. It has no Stokes component. The splitting of the beam into two parts passing through the benzene (upper half) and air (lower half) is clearly seen. Flashes 1 - 3 were made with Q modulation. They show clearly on the right of the Rayleigh component ω_0 the amplified Stokes component ω_s (upper part of each flash) and the unamplified weak Stokes component, passing through the air (lower part of each flash).

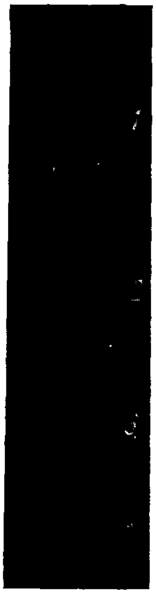

Figure 2

Photometry of the series of photographic plates (see the table) discloses amplification by a factor of 3 - 7 relative to the intensity of the Stokes component. The increase in the amplification coefficient at constant cuvette length with increasing pump power is clearly seen. The first experiments show that a receiver for coherent radiation can be constructed using the SRS phenomenon.

It must be noted that such a receiver has a sensitivity which is at least one order of magnitude higher than a receiver using a ruby amplifier. This is due to the fact that the half-width of the amplification spectrum of the ruby laser is one order of magnitude larger than the half-width of a typical Raman scattering line.

Photo plate No.	Lines	Photog. density rel. un.		Line intens. ratio		Gain	Remarks
		Benzene	Air	$\frac{I_\delta}{I_\ell}$	$\frac{I_\delta}{I_\ell}$		
1 bgrd. 3	ω_0	140	110	1,27			
		150	120	1,25			
		150	115	1.30		4	
	$\omega_0 - \Omega$	120	23		5.2		
		120	26		4.6		
		120	26		4,6		
22.6 bgrd. 2	ω_0	44	42	1	3	3	
	$\omega_0 - \Omega$	12.4	4.2				
22.4 bgrd. 2	ω_0	140	105	1.3		4	2-spike lasing mode
	$\omega_0 - \Omega$	100	83	1.2			
	ω_0	85	17		5		
	$\omega_0 - \Omega$	38	4		9.5	8	1-spike lasing mode
24.1 bgrd. 3	ω_0	100	85	1.2		5	
	$\omega_0 - \Omega$	100	75	1.3			
	ω_0	18	4		5	5	
	$\omega_0 - \Omega$	31	6		5		

[1] E. Woodbury and W. Ng , Proc. IRE 50, 2367 (1962).

[2] V. G. Platonenko and R. V. Khokhlov, JETP 46, 555 and 2126 (1964), Soviet Phys. JETP 19, 378 and 1435 (1964).

[3] V. M. Fain and E. G. Yashchin, JETP 46, 695 (1964), Soviet Phys. JETP 19, 474 (1964).

[4] R. W. Hellwarth, Phys. Rev. 130, 1850 (1963).

[5] Garmire, Pandarese, and Townes, Phys. Rev. Lett. II, 160 (1963).

[6] Akhmanov, Kovrigin, Strukov, and Khokhlov, JETP Lett. No. 1, 42 (1965) (Transl. p. 25).

[7] Minch, Terhune, and Rado, Appl. Phys. Lett. 3, 181 (1963).

[8] T. H. Dennis and P. E. Tannenwald, Appl. Phys. Lett. 5, No. 3 (1964).

---

1) This generator scheme with total-reflection mirrors and with the cuvette located inside the cavity has made it possible to observe generation of the Stokes component, followed by its amplification even without Q modulation. In the latter case the amplification of the Stokes component was smaller than with Q modulation.