agree with the observed values (1.5–3 msec). Identical values of $\Delta\tau$ for the optical and x-radiation are due to the generation of both radiations by the same electrons. A similar profile of the pulses at the radio frequency is possibly connected with the fact that the distribution of relativistic electrons responsible for the radio emission with respect to the pitch angles is influenced by the action of the powerful optical and x-radiation.

The received radiation becomes pulse-like if the angle β between the rotation axis ω and the magnetic dipole **M** is not equal to zero. When

$$\beta = \pi/2,$$

the radiation pulses, which are registered twice every revolution, follow at equal time intervals (this case is typical of most pulsars). On the other hand, if $0 < \beta < \pi/2$, then in the case of observation at an angle γ to the ω axis ($\pi/2 - \alpha < \gamma < \pi/2$) the intervals between three successive pulses become unequal (a situation typical of the NP0532 pulsar, and also of NP0527 and CP0950).

In the case of rotation of a star having a magnetic moment **M** not parallel to ω, a strong interaction occurs between the magnetic field and the plasma in the magnetosphere of the star and the surrounding medium (effects of plasma dragging, spin-off of matter, and radiation of low-frequency waves, which, in principle, may be responsible for the change of the period of the rotation of the object). The revolution frequency $\omega = 2\pi/\tau \sim 2-2\times10^2$ satisfies the inequalities $\omega < \omega_{Hi}$ or $\omega_{Hi} < \omega < \sqrt{\omega_{Hi}\omega_{He}}$, where ω_{Hi} and ω_{He} are the ion and electron gyrofrequencies in the plasma surrounding the pulsar, i.e., in the interstellar medium or in the supernova envelope. Therefore the radiated low-frequency waves correspond to Alfven waves or to waves in the region intermediate between magnetohydrodynamic waves and waves of the type of whistlers in the earth's magnetosphere. According to estimates by V. P. Dokuchaev and Yu. V. Chugunov, the power $W \sim W_0 n^3$ of the magnetic dipole radiation of a rotating star in a medium will be much higher (by a factor 10^6 and more) than the corresponding power in the vacuum W_0 (owing to the large values of n—the refractive index of these waves).

It is not excluded that the radiation of the low-frequency waves is the main cause of the observed growth of the period of rotation of the pulsar.

[1] V. L. Ginzburg, V. V. Zhelezhyakov, and V. V. Zaĭtsev, Usp. Fiz. Nauk 98, 201 (1969) [Sov. Phys.-Usp. 12, 378 (1969)]; the same, Astrophysics and Space Science (1969).

N. S. Kardashev. Possibility of Observing Extragalactic Pulsars.

The paper considers the following:

1. The possibility of observing pulsars produced in supernova outbursts of the nearest galaxies. At the instant of the outburst, the pulsar radiation power may be comparable with the radiation power of the supernova envelope. Subsequently, the pulsar radiation exceeds the envelope radiation power. It is noted that it is necessary to organize observations of supernova outbursts in the nearest galaxies. The observations are desirable in the γ, x-ray, optical, and radio bands for different instants following supernova outbursts.

2. The probable role of pulsars in radio galaxies and in quasars. There are three possibilities: 1) a decisive role in the radio sources is played by a supermassive star—s "superpulsar"; 2) in addition to the supermassive star there exists in the source a large number of ordinary pulsars, ensuring generation of cosmic rays; 3) the radio source consists of a large cluster of pulsars. A method is proposed for determining the number of pulsars in the source, the radiation of which is due to a considerable degree to the radiation of these pulsars.

3. The prospects of investigating extragalactic pulsars so as to determine the cosmological parameters, namely, measurement of the density of the intergalactic medium on the basis of the delay, measurement of the parallaxes at cosmological distances, and measurement of the expansion of the universe by determining the change of the periods of remote pulsars.

V. I. Slysh. Scattering of Pulsar X-rays in the Interstellar Medium.

The influence of the interstellar dust on the x-rays from the pulsar in the Crab Nebula NP0532 has been calculated. This influence reduces to pure small-angle scattering. Spherical particles of radius 0.5 μ scatter x-rays with wavelength 5 Å "forward" into a cone of approximate width 1.5′. In the case of NP0532 there is produced around the pulsar a halo with angle dimension 1–2′, containing about 90% of the total pulsar radiation. Since the structure of the x-ray source Tau XR-1 has the same character (the source of the pulse radiation contains 5–10% of the flux of the ex-nebula), it can be assumed that the radiation of the Crab Nebula itself in the x-ray band is small, and the observed nebula constitutes only the halo of the scattered radiation of the NP0532 pulsar. In this case the following should be observed: first, an increase in the fraction of the pulse radiation on going over to the harder region; second, an increase of the angular dimension of the nebula at longer wavelengths (~15′ at Å wavelength); third, a correspondence between the polarization characteristics of the pulsar and of the nebula. Analogous nebulas with a flux proportional to the interstellar absorption in the visible region should be observed also in other x-ray sources. If the scattered x-radiation is not observed, this will mean that the optical interstellar radiation is due to particles of much smaller dimension.

I. S. Shklovskiĭ. Concerning Pulsars

1. The age of the pulsar PSR0833-45, determined from the period T and its derivative dT/dt, turns out to be ~10,000 years, whereas the age of the radio nebula Vela X, with which this pulsar is identified, should be not less than 30,000–40,000 years. The probability of random coincidence of the coordinates of the pulsar PSR0833-45 and of the radio nebula is very low.

The observed discrepancy between the ages of the pulsar and the nebula can be attributed to the large number ($\sim 10^4$) "collapses" of the period and the associated changes of dT/dt. A similar situation (but with opposite sign) occurs apparently in the case of CP0950, for which dT/dt is anomalously small ($\sim 3 \times 10^{-16}$), and therefore the "age" turns out to be unreasonably large for a pulsar with a relatively short period. A similar effect takes place apparently also in the case of the pulsar NP0532 in the Crab Nebula.

2. Attention is called to the fact that the tangential velocity of NP0532 is anomalously large, ~150 km/sec. It is possible that the tangential velocity of PSR0833-45 is also of the order 100–200 km/sec. This reinforces the result of V. V. Vitkevich, obtained from the analysis of the fluctuations of the amplitude of the pulses of pulsars, that the tangential velocities can reach 1000 km/sec. The reason for such large pulsar velocities may be the "sling effect" or the asymmetry of the ejection of the matter during the time of the supernova outbursts.

3. An attempt was made, within the framework of the model of rotating neutron stars, to obtain a general idea of the directivity pattern only from an analysis of the result of the observations, without involving any hypotheses concerning the mechanism of pulsar radiation. The total number of pulsars in the galaxy can be estimated at $\sim 3 \times 10^4$. If the average age of the pulsars (whose periods are $\sim 1^S$) is $\sim 10^7$ years, then the frequency of pulsar production in the galaxy is about once every few hundred years, in good agreement with the frequency of the supernova outbursts. If the directivity pattern were to be "pencil-like" with an aperture angle $\sim 10°$, then the total number of pulses would be larger by one order of magnitude and the frequency of their formation would be unreasonably large. This argument favors the "knife-like" diagram. Another argument favoring such a diagram is the very fact of the presence of observable pulsars in such well known peculiar objects are Vela X and the Crab Nebula. It would be strange to assume that in addition to all their surprising properties these pulses have one more and perhaps the most curious property, namely the axis of their "pencil-like" diagrams point to the earth. The PSR0833-35 model recently proposed by Radhakrishnan, with a "pencil-like" diagram, is incorrect, since it does not account for the observed almost 100% linear polarization of this pulsar.

Finally, the fact that the interpulses are never observed accurately in the middle of the period is a serious argument against the model of Radhakrishnan and favors the "knife-like" diagram. A difficulty of the latter is the interpretation of the unequal magnitude of the amplitude of the pulse and the interpulse. This difficulty can be eliminated by introducing the concept of the presence of a certain polar diagram in the plane of the "knife," which in turn should be perpendicular to the magnetic axis of the pulsar. Thus, the proposed model corresponds to radiation in two almost parallel planes perpendicular to the bundle of forced lines emerging from the northern and southern magnetic pulse, respectively.

4. The mechanism of pulsar radio emission should reduce to a certain coherent process. If these are plasma oscillations, then it follows from simple energy considerations that the plasma should be relativistic. Transformation of the longitudinal plasma waves into transverse electromagnetic waves by stimulated scattering indicates that the pulsars can be regarded as masers. Under real conditions these masers are always saturated. Under such conditions, the power of the radio emission is determined by the power of the "pumping" mechanism. Since in the case of NP0532 this mechanism should also ensure radiation that is more intense by millions of times in the optical and the x-ray bands, the simple transport of particles from the surface of the neutron star into the generation region, as can be readily shown, is insufficient. The "pumping" can be ensured only by a powerful and very effective acceleration mechanism, which compensates for the tremendous losses of the relativistic electrons to radiation. Such a mechanism may be, for example, the acceleration of plasma particles by the magnetic dipole radiation of a rotating neutron star, considered by Ostriker and Hahn.

5. The most natural mechanism of optical and x-radiation of NP0532, in our opinion, is the inverse Compton effect of the relativistic electrons (which are responsible for the coherent radio emission) on the radio quanta. Favoring this assumption is, in particular, the practical absence of delay between the start of the radio and optical pulses. The energy of the relativistic electrons, obtained from the condition of transformation of the radio quanta with frequency $\sim 5 \times 10^{17}$ Hz into optical quanta, is $E \sim 10^9$ eV. The concentration of the plasma electrons is then $\sim 3 \times 10^{11}$ cm^{-3}. To ensure the observed power of the optical radiation it is necessary that a lifetime of such electrons be $\sim 10^{-7}$ sec, which is ~1000 times larger than the value that follows from the simple theory with allowance for the value of field of the radio quanta in NP0532. However, at high energy density of the radio quanta, a major role can be played also by stimulated inverse Compton effects. This leads to maser effects and ensures a sufficient directivity of the optical radiation.

The theory should explain why optical radiation is observed only in NP0532. The answer apparently is that in NP0532 the energy density of the radio emission in the generation region is larger by hundreds and thousands of times than in other pulsars. This circumstance contributes to transformation of the radio quanta into optical quanta via the stimulated inverse Compton effect.

V. V. Vitkevich, I. F. Malov and Yu. P. Shitov. Concerning the Model of a Pulsar as a Rotating and Pulsating Neutron Star.

It is indicated in the communication that it is impossible to account for the second-class periods of pulsars by starting from the hypothesis of a pulsating neutron star, since the observed periods exceed the permissible pulsation periods (for example, the second-class period of CP0808 is 53 msec, and the permissible periods are ~10 msec). An attempt is made to represent the pulsar as an unstable compressing object. It is shown that in this model one obtains a decrease in the period of revolution, and this contradicts the ob-