posals, original and fruitful. Taking at random:

28 July, 1925 and the subject is the teaching of history.

The next day he is commenting on the standardization of scientific terminology.

26 July 1927, he drafts with Mme Curie a proposal regarding the role of the Institut de Paris.

His longest interventions are those of 24 July 1930 on the subject of teaching programmes and the dissemination of culture.

A few days later, he is participating in the discussions on the programme, work and organization of the Commission, and the Institute.

The other side of the collaboration of Einstein with the Commission relates to the sub-committee on the sciences and information systems. Minutes of its meetings reflect the presence of Einstein and in a certain way bring him to life for us. It would be tedious to mention all the subjects discussed, all the resolutions made and adopted by the sub-committee. Let us just say that they relate to the coordination of scientific information systems, library organization, exchanges of publications as well as different disciplines and their teaching.

Einstein as a Person

The above digest is but a brief resumé of various notes made during long readings, but it serves at least to mark the passage of Einstein through the Commission for Intellectual Cooperation, the work of which is now covered by UNESCO.

The business of international relations as we know from our own experiences in the European Physical Society is, for the minor part inspiration, and for the very large part mundane administration, in which often the little details require a disproportionate effort spent on them. That Einstein was prepared to concern himself with such matters shows us an aspect of his character that is not always appreciated. We are all conscious of his huge intellectual powers, his deep humanism, but we are frequently left with the image of a solitary figure, hair blowing in the wind, a sort of mystic living in the abstract. In his committee work, we find him also willing to become involved in the tedium of organizational affairs, aware of the boundary conditions imposed by practical politics, a man living in the world, sensitive to its tragedies and alive to the need to tackle the small practical problems that are within reach.

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Evidence for Gravitational Waves More Successes for GR

M. Lachièze-Rey, Saclay

Latest measurements on the characteristics of the radio emission from the binary pulsar PSR 1913+16 provide strong evidence for the existence of gravitational waves and support the conclusions of General Relativity in a remarkably consistent way. This then is the fifth major confirmation following the predictions of:

1) the advance of the perihelion of Mercury

2) the gravitational redshift of spectral lines

3) the deflection of light by massive objects

4) the radar echo delay dependency on gravitational fields.

Background

It was in 1974 that PSR 1913+16 was discovered — an object of such relevance to General Relativity that it constitutes a specialized laboratory in itself. Radio emissions from it, showed it to be a very condensed object (neutron star) rotating very rapidly, with a period of 59 ms, while periodic slight variations of the frequency revealed that the pulsar was orbiting around an invisible companion. Since no eclipse was observed, this companion had to be compact. Dispersion measurements indicate that no plasma is present in the region of the orbit, and the system is therefore sufficiently « clean », in the sense that no tidal interaction or mass transfer occurs, that observation of purely relativistic effects is possible.

Very accurate observations were initiated soon after the discovery of the pulsar, which led in the years 1975-76 to a most important first result[1]), namely that the periastron shift of the orbit (analogous to the perihelion shift of Mercury) is 4.22°/a (compared with only 43"/a for Mercury). The mass of the binary system could thus be inferred from the equations of General Relativity as 2.8 solar masses[2]) — the first time that the theory had been used to derive a physical quantity.

Latest Results

Details of new measurements and their interpretation were presented at the IXth Texas Symposium in Munich, 14-19 December, 1978. For four years, J. H. Taylor and his coworkers have been making very precise pulse measurements at the radio telescope of Arecibo in Puerto Rico, increasing the accuracy to about 1 %. Undoubtedly, the most important was the measurement of the rate of change of the orbital period which gave the result that:

$dB/dt = -3.2 \pm 0.06 \times 10^{-12}$

This is in excellent agreement with the predictions of General Relativity which on the basis of energy loss through the emission of gravitational radiation gives a value within a factor of 1.3 ± 0.3.

Taylor has examined explanations alternative to that of the emission of gravitational waves but they appear quite ad hoc and fail to match the observations by more than one order of magnitude. Consequently, it is difficult not to follow him in concluding that gravitational waves really do exist and carry away energy at the rate predicted by General Relativity.

Other parameters of importance that could be determined by the team were the: 1) Time delays due to both transverse Doppler shift and gravitational redshift, which give a ratio of about unity for the masses of the pulsar and its companion; i.e., each has a mass of about 1.4 M_O. 2) The sine of the inclination angle between the plane of the orbit and that of the sky to an accuracy of 20 % — impossible to do by classical methods.

Conclusion

This series of measurements on PSR 1913+16 has allowed us to take a major step forward in our knowledge of the fundamental laws of gravitation. GR has been confirmed at the post-newtonian level and beyond, and it has been used for the first time to derive physical parameters. In a compelling way the existence of gravitational waves has been made to appear very likely and stringent constraints have been set upon alternative theories of gravitation.

References

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