In Appreciation of Joshua Goldberg (1925 – 2020)

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Abstract

Joshua Goldberg was a seminal contributor to relativity theory, both through his own original work and his function as an administrator of US Air Force research funding. He is perhaps best known for his work on algebraically special solutions of Einstein's equations, yet he also helped pave the way to our understanding of the generation and propagation of gravitational waves. He was in addition a leader in the exploration of the use of null surfaces and the description of asymptotic fields. I will give a brief overview of this work, frequently citing Josh's own comments in a series of interviews I recorded with him.

For more information please refer to the chapter entitled Joshua N. Goldberg to appear this summer in The Golden Age of Space-time, edited by Daniele Malafarina and Susan Scott. The chapter also contains contributions by Abhay Ashtekar and David Robinson.

Biography

Early life and education

- Born 1925 in Rochester, New York. Parents were Russian emigrés
- B. S. in physics from University of Rochester, 1947. Education interrupted by Navy service leading to post-victory deployment in the Philippines
- Began graduate study at Syracuse University in 1947, earning Ph. D. in relativity theory under Peter G. Bergmann in 1952.

Research and academic positions

- Armour Research Foundation, 1952 - 1954.
- Aerospace Research Laboratories, Wright Paterson Air Force base, 1956 - 1963
- Post-doctoral Fellow, Kings College, London, 1960 – 1961
- Syracuse University Department of Physics, 1963 – 1995. Served as Department Chair, 1976 - 1979

Gloria and Josh in Sestriere, Italy, 1958

Early Recollections

High school: "I had a fantastically good physics teacher."

Exposure to relativity at the University of Rochester? "I was taking German. The German teacher asked me to translate a scientific article. This was after coming back. So I spoke to Julius Ashkin at the time who was teaching me mechanics and thermodynamics and theoretical physics and a few other things at that level, and he said, "Gee, it would be a great idea. Why don't you translate Einstein's paper?" The 1905 Special Relativity."

Graduate School

The central focus of Josh's thesis was the explicit demonstration of the link between the general covariance of general relativity and the iterative approximation procedure that had been introduced by Einstein, Infeld, and Hoffmann to deduce particle equations of motion.

The EIH procedure was based on what they called 'the lemma', a consequence of the fact that the field equations contained an anti-symmetric contribution. Peter Bergmann made the first step in 1949 in tracing the origin of this contribution to general covariance. Josh exploited the fact that general covariance leads to a strongly conserved pseudo stress-energy tensor. Strong conservation means that its divergence vanishes whether the field equations are satisfied or not. It follows that this pseudo tensor can in turn be written as an antisymmetric superpotential, and this antisymmetry was precisely what he had sought to find.

Armour Foundation and the Aerospace Research Labs

"When I went to work at Wright Paterson I was alone. I was the only member in that group. I was forming a group. I didn't know I was going to form a group. And my job was two-fold. One, to do research in general relativity. And the other to distribute funds to active research people who were interested in being supported by the Air Force. And there was sort of a third dimension as well. And that is to be available and to review crazy proposals."

Art Komar, Peter Bergmann, and Josh at the Warsaw relativity meeting, 1962. Paul Dirac In the foreground.

Josh's *US Airforce Support of General Relativity: Chapel Hill 1957 and Beyond to appear in the Spring 2021 History of Physics Newsletter.*.

Major Research Achievements

Equations of Motion and Gravitational Radiation

Major innovations: Focus on Riemann tensor and correct tracking of coordinate conditions in *v/c* expansions – 1955, Work with Havas on `fast motion` approximation, with pioneering treatment of Green function divergences – 1962, Influential joint work with Ehlers, Rosenblum and Havas summarizing inadequacies of all current gravitational back reaction procedures - 1976

On a conversation with Einstein in 1954: "And I explained to him the issue of strong conservation, which he probably knew, but had never expressed it. But nonetheless, I thought I was telling him something new. I've always afterward been a little embarrassed by that thought. But, so it goes. Anyway, he did seem interested. But he was not really interested in equations of motion. If I come to him and show him a plane wave solution, any wave solution, he would have been ecstatic, but he was not interested in radiation from moving particles."

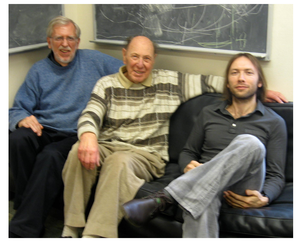
Goldberg-Sachs theorem

Prior to 1962 it had been known that all algebraically special solutions to Einstein's vacuum equations possessed shear-free null congruences. Goldberg and Sachs proved the converse in 1962.

"Ray and I used two things. One was we used the Bianchi Identities, but we only used part of the Bianchi Identities. I think we used the differential part, not the symmetry. Well, they're both differential, but one was the dual of the other. So we could get half of the theorem, and we didn't know how to get the other half. What was hard was proving the other. And if we had taken the other half of the Bianchi identities, the dual, then it would have been equally easy. But we didn't. What we knew at that time was the Robinson Trautman work. So Ray said, go talk to Trautman, because Trautman happened to be in London at the time. He wasn't with Bondi, but he happened to be in London. So I went to talk with Andzrej, and we examined how he and Ivor derived certain results. And it was an ahha moment. So that which should have been treatable through the Bianchi identities, if we had taken the dual."

Self-dual fields and Ashtekar variables

Josh's familiarity with Newman's *H*-space and Penrose's twistor program led him to discover a new geometrical approach to Ashtekar's gravitational field variables. The outcome in 1988 was a new derivation of the Ashtekar constraint algebra and the associated symmetry transformations.



Myself, Josh, and Dean Rickles – March 2011 In Syracuse.

Null surfaces and asymptotics

It was natural that in the late 1980's Josh would turn his attention, with collaborators David Robinson and Soteriou, to canonical formalism on null surfaces. Prior to this he published in 1963 the first in a long series of articles dealing with the asymptotic behavior of gravitational fields. Most dealt with the behavior along null rays, being inspired by Sachs' 1961 pioneering investigation in which Petrov types fell off with varying inverse powers of the radial coordinate. The use of the related Newman-Penrose approach in 1967 led to his most cited collaboration (with Macfarlane, Newman, Rohrlich, and Sudarshan).

A comment on Penrose and Newman (who passed away on March 24, 2021): "Ted's original way of doing things was not spinorial. That's why if you look at their papers, you can tell which part Ted did. They work differently, but conceptually they were on the same track. That's incredible that they always worked that way, that Ted would come up with some crazy idea in his way of thinking, and Roger would figure it out spinonrially. And it would look very different, but it's the same. They really worked in parallel and independently."

A Parting Thought

"We're looking for an overarching principle. Anything we find may be in conflict with general covariance and I'm not, and I hope that my friends are not die hards so that they'll insist that general covariance is an ultimate requirement that they refuse to give up in any case."