Ivor Robinson and the Trautmans: Gravitational Wave Pioneers

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Focus of this talk:

- Symmetry-based paths culminating in collaborative gravitational wave exploration by Andrzej Trautman and Ivor Robinson
- Relation to work by Leopold Infeld, Peter Bergmann, Joshua Goldberg, Felix Pirani, Hermann Bondi, Rainer Sachs, and Róża Michalska-Trautman

Ivor and Andrzej Trautman,
Trieste, 1991

Timelines

Ivor Robinson

- 1950 Cambridge Bachelor in Mathematics
- 1950 - 58 Lecturer University College Wales
- 1959 Visit Trautman in Warsaw
- 1959 - 60 University of North Carolina
- 1960 - 61 Syracuse University
- 1961 - 62 Cornell University
- 1962-63 Syracuse University
- 1963 - Southwest Center for Advanced Study

Andrzej Trautman

- 1955 Masters in Engineering at Politechnika Warszawska
- 1957 Pirani visits Warsaw
- 1958 Trautman lectures at King's College, London
- 1959 Warsaw Ph. D. under Infeld
- 1959 - 60 University of North Carolina
- 1961 Spring and summer, Syracuse University
- 1964 Brandeis lectures with Pirani and Bondi
- 1967 Syracuse University

Recounted in Neeman Festschrift [Robinson, 1985] and Robinson Festschrift [Rindler & Trautman, 1987].

Led first in 1955 to Einstein-Maxwell constant electromagnetic field, Bertotti-Robinson spacetime. Published in Poland in 1959 at Infeld's insistence [Robinson, 1959].

Next discovery was that the product 2-spaces he had been studying admitted a plane electromagnetic null wave - with associated geodetic null congruences, showing in 1956 that the congruences were also shear free.

1956 realization that null rotation symmetry method led to coordinate singularity-free gravitational plane wave. Reported same year at King's College and Cambridge - but not published. Bonnor refers to it [Bonnor, 1957]

Paper with Bondi and Pirani [Bondi *et al.* , 1959] generalizes from five parameter symmetry group of plane flat space electromagnetic waves to plane-fronted gravitational waves.

Exact plane waves were shown to be of Petrov type *II*.

Trautman thesis and King's College lectures

1958 lectures based on series of publications in *Bulletin de l'Académie Polonaise des Science* now finally available in Golden Oldie Series, [Trautman, 2002]

Accomplishments

- Correct Sommerfeld boundary conditions for gravitational waves. Inspired by [Goldberg, 1955] higher order Einstein Infeld Hoffman (EIH) approximation
- Gravitational news function respecting Lichnerowicz continuity conditions
- Correct Trautman-Bondi mass loss fomula. See [Chrusciel *et al.* , 1998]

Trautman symmetry and conservation laws

Recognition of general covariance symmetry origin of EIH derivation of equations of motion, with reference to [Bergmann, 1949] and [Goldberg, 1953]

Two routes to equations of motion available, with theoretical foundations thoroughly detailed in classic [Trautman, 1962], elements recognized in [Trautman, 1956b], [Trautman, 1956a], and [Trautman, 1957], based on strong conservation laws.

- Original EIH and Goldberg followup based on singular sources and metric dynamics.
- Covariantly conserved stress-energy, Einstein equations integrability conditions.

Trautman identified apparent failure of slow motion approximation in connecting to the gravitational wave zone.

The Robinson Trautman collaboration

Quotation from [Rindler & Trautman, 1987]: "During the 1960s and 70s, a systematic search for algebraically degenerate solutions of Einstein's equations produced remarkable results. Ivor's own initiative led to the discovery of a large class of gravitational fields with expanding, non-shearing geodesic rays."

- [Robinson & Trautman, 1960] and
  [Robinson & Trautman, 1962]. Exact spherical wave solutions
- Exact solutions exhibiting asymptotic "peeling off" behavior analyzed by Sachs, [Sachs, 1961] and [Sachs, 1962]

Róża Michalska-Trautman published post-humously with Infeld [Infeld & Michalska-Trautman, 1969] a calculation of gravitational back reaction.

Paper was cited by [Chandrasekhar & Esposito, 1970] as correctly anticipating their comprehensive post-Newtonian approximation scheme.

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