Texas Symposium on Relativistic Astrophysics

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The Route to the Einstein/Einstein-Maxwell Metrics of an Uncharged or Charged Spinning Particle.

abstract,

We describe the slightly tangled story that begins with the spin-coefficient equations of Newman and Penrose and ends with a complex coordinate transformation applied to the Schwarzschild and Reissner-Nordstom metrics. Along the way we see the origins of the Kerr and the Kerr-Newman metrics.

I thank the organizers, Wolfgang Rindler and Don Salisbury, for having inviting me to talk about this rather messy tale.

I have never told it publicly before.

☑ Journey starts with Spin-Coefficient formalism (NP) – arguably much earlier with Petrov or Cartan, or with Ivor Robinson, Herman Bondi, Ray Sachs

☑ Rather useful formalism – simplified study of asymptotic radiation theory, reproduced easily many of the know results;

e.g., the Bondi -Trautman energy-momentum theorem, the beautiful Goldberg-Sachs Theorem, Robinsons Peeling theorem

☑ Became very useful in the study and discovery of exact solutions, examples; Mainly algebraically special, Robinson-Trautman, Type-N, NUT, geodesic rays

☑ Why were the NP equations so useful?

☑ A very large number of variables – depending on counting ~ 33. many complex. Quickly reduced to fewer

☑ Many equations –
depending on counting ~ 34
- Often long and complicated

☑ Easily allowed special cases even before calculations were begun. Algebraically Special

☑ Several drawbacks - too many variables to remember,
AND VERY EASY to PRODUCE MISPRINTS.
- Many in the first publication – corrected a year later.
- e.g., Illegal “equal” signs in one.
- A terribly wrong minus sign in another.
- Part of the tangled story

MAIN PART OF THE TANGLE

☑ Nov 62, N., U., T., submitted manuscript to JMP

☑ Contained Two Claims

- New Metric, the NUT space metric
- Non-existence of a class of metrics

☑ Manuscript sent to Alfred Schild for Refereeing

- Passed to Junior colleague, Roy Kerr, to referee

☑ Contacted by Kerr, informing me of error

- Non-existence of a class was wrong – class exists
- we met and tracked the error to sign misprint in NP

☑ $\alpha = -\alpha, \Rightarrow \alpha = 0$ **should** have been $\alpha = \alpha$

- α turned out to be the Kerr parameter

☑ Revised manuscript sent back to JMP.

- Published in July 1963.
- NP Errata also published in July 1963

☑ Kerr and Alan Thompson – Kerr's friend and colleague, were explicitly thanked in revised manuscript.

☑ Kerr worked out corrected metric,
α NOT zero.

- known as Kerr metric
- Submitted 1963 – same month as NUT published
- Kerr went on to deservedly great fame

☑ to illustrate this fame I quote from an interview from last year from a New Zealand newspaper.

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"…….when at only 29, he (Kerr) cracked a mathematical conundrum which had been stumping relativity theorists for 50 years and so proved black holes could exist.

….

Yet there are those who still wonder how Kerr has been overlooked for the Nobel (Prize) despite being nominated several times. ……."

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KERR and EINSTEIN Photo

☑ It is generally acknowledged that Kerr solution is one of the most important solutions

- and it belongs to Kerr
- we goofed
- as a good referee, Kerr saved us from embarrassment
- and again, we thank him for that

☑ **BACK to the Main Story**

☑ Correction put back into NP machinery & knowing Kerr metric.

☑ Simply by looking at Eqs & Kerr it **seemed**
Schwarzschild => Kerr
by a complex coordinate transformation

$r' = r + ia\cos(\theta), \qquad u' = u - ia\cos(\theta).$

- Schwarzschild null tetrad & Metric
(l^a, n^a, m^a, m^{*a}),
$g^{ab} = l^a n^b + n^a l^b - m^a m^{*b} - m^{*a} m^b.$

- Then a (formal) complex coordinate transformation on the tetrad vectors:

- a bit of tweeting, e.g., $1/r \Rightarrow \frac{1}{2}\{1/r + 1/r^*\}$

- NEW tetrad (l', n', m', m'^*) into

$g' = l'n' + n'l' - m'm^{*'} - m^{*'}m'$

=> the Kerr metric.

☑ Next thing to try – same complex coordinate transformation on Reisner-Nordstrom metric.

- another TWEET on the null tetrad,

  1/r^2 => 1/rr*

☑ Not obvious – needed to be checked - a new solution of Einstein-Maxwell Eqs.

- Often referred to as Kerr-Newman

♥♥♥ To avoid nomenclature confusion, we remark that Kerr, in his published work, prefers to refer to this metric as the charged Kerr metric

Three Remarks to End this Tangled Tale

1. ☑ We missed it. Brandon Carter pointed out gyromagnetic ratio of Kerr-Newman was Dirac value

- g = 2

- ☑ Several Russians made attempt to associate it with Dirac particle

2. ☑ We misinterpreted the nature of the source of Kerr and Kerr-Newman. Kerr and Penrose pointed this out to us.

- Details of the source structure was worked out by Gerry Kaiser

3. ☑ Is there something deep that is associated with the complex coordinate transformations? Maybe, BUT……

Dates of Some Related Papers,

1. NP formalism (received sept 61, pub1962),
2. Newman-Unti, Asymptotic properties (1962),
3. NUT space (received nov.62, pub. july1963),
4 . Kerr metric (received july1963, pub. sept 63),
5. Janis -Newman (received June 64, pub.1965)
6. Kerr-Newman (received, June 64, pub.1965),
7, Demianski-Newman (1966)