

History of Twice-Lost EMTFD Equations

The first time Bass derived the ElectroMagnetoThermoFluidDynamic (EMTFD) equations, he was working at what is now the Princeton Plasma Physics National Lab (PPNL), and in his spare time, 1957-59, started writing out the details of the 720 terms, in the determinant of the relevant 6-by-6 matrix mentioned above, on large sheets of paper, about a yard square each, and continued through completion in 1962.

The problem is to find the coefficients of a polynomial, each of whose complex roots, ω , gives the frequency [imaginary part] and damping ratio [real part, assumed negative] of an exponentially-damped sinusoidal EMTFD wave which takes into account all four transport coefficients [thermal conductivity κ , hydrodynamic viscosity μ , electrical resistivity η , and displacement current, given by taking the speed of light c to be finite, i.e. by specifying $(1/c) > 0$, rather than using the MHD approximation $(1/c) = 0$].

Each of these 4 coefficients has to be carried along symbolically rather than numerically.

Each of the 720 terms in the relevant determinant is a multinomial of up to the 4th degree in these 4 symbols, plus another described below, so it can be seen what a large problem in symbolic algebra it is to complete!

Indeed there is a fifth symbolic coefficient, Λ^2 , which is one of the Helmholtz Numbers [also called eigenvalues of the Laplacian] found by solving Laplace's equation in the relevant geometry.

In the present context, that would be the **spherical annulus** between two concentric spheres, the inner one of radius 4,000 miles and the outer one of radius 4,040 miles as in the pictures excerpted from **Article 30**: Stan Gibilisco, "Alternative Energy DeMystified," McGraw-Hill, 2007, Covers & excerpt <http://www.innoventek.com/GibiliscoAlternativeEnergy.pdf> [although Gibilisco conceives of the **Earth-Ionosphere** Cavity as an electrostatic Capacitor rather than the realm of dynamic EMTFD Resonant waves].

Bass estimates that it took him ~200 hours/year, for ~5 years, before he was finally able to write down the formulae for the 6 coefficients on a single sheet of paper, in less than one line each [because the myriad terms started canceling each other when finally collected].

When Bass was General Manager of Aeronca Mfg. Corp.'s Aerospace Division, the company agreed to hire a full-time employee for the sole purpose of checking the algebraic correctness of Bass's previously-derived & personally-owned EMTFD work. After ~half a year, she

had verified ~half of Bass's algebra, and Aeronca lost interest and gave her another assignment, and later Bass left, but did retain his original copy of the one-page version of the formulae.

Since 1986, in preparation for departure to Egypt for a year, Bass has been paying more than \$150.00/month for Dead Storage of 400 cartons of books & papers, covering 35 years of his work [from 1950 through 1985], occupying ~500 cubic feet and weighing ~13 tons. It is possible that the single page from Aeronca is among those papers, but, realistically, it would take more work to sort carefully all 400 cartons of papers than to re-derive the formulae from scratch, and, moreover, the page may NOT be there!

However, when Bass had been on the faculty of BYU, 1971-81, he had still had that one page and verified the validity of his formulae to some extent by using the university's computational facilities to work some numerical rather than analytical examples, which agreed in all cases tried.

In his BYU Topolotron Patent cited above, the equations were explained in sufficiently general terms to be re-derivable by others, with sufficient diligence, but mainly to point out fatal errors committed in attempting the same algebraic feat by astrophysics Nobel Laureate Chandrasekhar's top student Dr. S.K Trehan, and, in an independent attempt, by Prof. Bruno Coppi of MIT.

Unfortunately Coppi had tried to obtain the general answer by solving 4 separate simpler problems, when each of the 4 transport coefficients mentioned above were set equal to zero separately, one at time, yielding 4 different hexadic polynomials, and then interpolating between these 4 separate answers.

However, the facts explained above about the lowest order term of the 6th degree polynomial being the product of all 4 transport factors [when $\Lambda^2 = 0$] make it clear that this attempt was foredoomed to failure!

Indeed, the hexadic polynomial then becomes a 5th degree polynomial, which has a linear factor (providing only entropy waves) multiplied by the two quadratic factors whose roots give the known Nobel Prize-Winning "fast" & "slow" MagnetoSonic waves [modified sound waves], also called Alfvén Waves.

Finally, when Bass was prematurely "retired" for 24 months, during 1996-1997, and had access to a Student Version of MATLAB with a Maple Symbolic Algebraic engine, he repeated the complete derivation project from 1957-1962 all over again, this time breaking the problem into smaller and smaller pieces until they could be handled by the Maple engine, and then putting them back together again.

This required literally hundreds of hours of typing because the Maple Engine of those days could not handle very long strings.

Eventually he completed the entire project and was able to type all 6 symbolic formulae for the 6 coefficients of the EMTFD hexadic polynomial on six separate lines, taking up only a portion of a single page, and he sent the 6 formulae to the MIT Plasma Physics Lab along with an Application for an important job, which he did not get, with also a separate "copy to Coppi."

In this page it was explained that the roots of the two known quadratic factors ["known" in the sense that they agree with those of Alfvén when one takes $(1/c) = 0$] are just generalizations of the Fast & Slow MagnetoSonic waves of Alfvén, whereas the hitherto unknown quadratic has roots which provide the Bass ElectroMagnetoSonic Waves [modified electromagnetic waves] or EMTFD waves.

Sadly, Professor Coppi told Bass at a meeting in 2007 that he didn't remember receiving his letter, and in any case no longer had it, and the HR people at MIT say they no longer have the 1997 Bass job-application that contained the 6 explicit algebraic formulae.

But Bass surmises that if the President of MIT were to strongly demand a better search, both copies would be found, and in the sense of Patent Law these formulae are now in the public domain, because they have been shown to "at least half of the world's leading experts in the most relevant arts," namely to Prof. Coppi (but not yet to Dr. Trehan).