Giovanni Venturi
selected scientific papers

Sergio Zerbini,
Department of Physics//Trento University
Trento

About Gianni

Undergraduate Sidney University 1962
Master Bologna University 1964 supervisor B. Ferretti
PhD Chicago University 1968, supervisor R. Oehme
Post Doc Rockfeller University and Cambridge University 1968-69
Permanent position Bologna University since 1970 to retirement as full professor in theoretical physics
141 published papers, single author 39
Collaborators (not all listed), * master or PhD Gianni's students
Tronconi* 37
Vacca* 27
Kamenshchik 25
Finelli* 24
Casadio* 15
Righi* 11
Marozzi* 10
many others including A. Starobinsky

Overview

Years 1966- 1974 High energy physics phenomenology
Years 1975-1977 Old String theory
Years 1976-1980 Non linear approach to gauge theory, mainly QED in non linear gauge
Year 1981 cosmology paper: dS solution in scalar invariant gravitational model
Year 1983 Time in semi-classic gravity: Born-Oppenheimer approach to Quantum Gravity (with R. Brout)
Year 1984 to today: several issues including black hole physics, inflation,
cosmological models, applications of BO approximation to inflation, high energy physics, ..
I will restrict to the first two underlined issues, but many others are also significant.

First selected issue: Non linear approach to ED

Several papers with his student Roberto Righi.
Original idea Dirac (1951,1952). Then Nambu (1968) and recently others with connection to Spontaneous Lorentz Symmetry Breaking.
Main idea: **choose a suitable gauge condition** to describe physics one is interested in.
Starting point ED in vacuum within a **non linear gauge**

$$I = \int d^4x \left(\frac{F^2}{4} - k(x)(A^2 + \lambda) \, , \right) \quad F = dA$$

Eqs. of motion

$$\partial^\mu F_{\mu\nu} = k(x) A_\nu \, , \quad A^2 = -\lambda$$

Look for vacuum spherically symmetric static solution
Thus

$$A_0'' + \frac{2A_0'}{r} = k(r) A_0 \, ,$$

Requiring **continuity** and $k(r) = A\delta(r - r_0)$

$$A_0(r) = \frac{m}{e}\left(c_1\theta(r_0 - r) + (\frac{r_c}{r} + c_1 - \frac{r_c}{r_0})\theta(r - r_0)\right) ,$$

where c_1 and r_0 are arbitrary constant quantities, and $r_c = \frac{e^2}{4\pi m}$, classical electron radius.
With a suitable choice for λ

$$A_i^2 = A_0^2 - \frac{m^2}{e^2} ,$$

If we put $r_0 = r_c$ and $c_1 = 1$, one has

$$A_0(r) = \frac{m}{e}\left(\theta(r_0 - r) + \frac{r_c}{r}\theta(r - r_0)\right) ,$$

For $r < r_c$ a constant potential. For large r, a Coulomb behavior. Amazing! an extended **non singular** spherically symmetric static solution regarded as charged particle!

Choosing $c_1 = -1$ another solution with **non trivial behaviour** at infinity

$$A_0(r) = \frac{m}{e}\left(-\theta(r_0 - r) + (\frac{r_c}{r} - 1 - \frac{r_c}{r_0})\theta(r - r_0)\right) ,$$

A static finite energy solution with constant electric field at spatial infinity: charged shell-like structure.
With this solution, a **topological conserved current** can be construct, with a topological charge N
Normalizing A_i, one deals with a S^2 manifold onto which the sphere at infinity is mapped with associated homotopy group $\Pi(S^2) = Z$.
Introducing an intertwining operator O

$$[N, O] = O \quad [N, O^*] = -O^*$$

The topological charge N is proportional to electric charge.
Conservation and discreteness for the electric charge!

Soft photon emission

Recall that in usual approach to QFT, infrared divergences (IR) arise in S matrix with mass-less particle.
Recently the presence of IR divergences has been related to memory effects in gauge theories (ED and GR). The memory effects states are not in Fock space. Thus IR divergence are not physical, and can be avoided with the introduction of IR regulators.
In the paper "Quantum Electrodynamics in a Nonlinear Gauge and Soft Photons" Gianni and his student R. Righi were able to provide a **suitable choice** for the photon field A_μ, satisfying the non linear gauge condition $A^2 = -\frac{m^2}{e^2}$. Thus the emission of soft photons in a scattering process was **free from IR divergences**! Achieved in the regime where the field is small with respect to $\frac{m^2}{e^2}$.
In GEOMETRICAL FORMULATION OF ELECTRODYNAMICS Gianni proved the equivalence of his formulation with usual Lorenz gauge formulation.

Conformal invariance in the Non Linear Approach to ED

In the paper "Conformal Invariance and the Fine Structure Constant in a Non Linear Approach to Electrodynamics " Gianni and his student investigated the behaviour of their formulation of ED under conformal transformations.The conformal group $SO(n,2)$ leaves invariant the flat metric η in R^{n+2} with signature $(n,2)$.The usual conformal group $SO(4,2)$ is a 15 fifteen parameters Lie which consists in Inomogeneous Lorentz transformation with dilatation and special (non linear conformal transformation and leaves M_4 invariant.

$$I = \int d^4x \left(\frac{F^2}{4} - k(x)(A^2 + \lambda) \, , \right) \quad F = dA$$

is conformal invariant only if $k(x) = 0$ or $\lambda = 0$. Thus

$$\partial^\mu F_{\mu\nu} = k(x) A_\nu \, ,$$

is OK, but the conformal invariance is **lost for** $A^2 = -\lambda$.

A first possibility is to introduce a dynamical field instead of λ. More interesting the extension to the invariance group to $SO(5,2)$, interpreting dynamically λ as the zero component on M_5 of a five dimensional photon field satisfying

$$-A_0^2 + A_i^2 + A_4^2 = 0\,,$$

Conformal invariance is OK, but one has to deal with an extra spatial dimension, some difficulty in its physical interpretation. However, there is a bonus within this approach: the quotient space decomposition of the related group $SO(5,2)$ gives an expression for the the electromagnetic fine-structure constant

$$\alpha = \frac{9}{16(120)^{1/4}}\pi^{-11/4} = \frac{1}{137.036082}$$

in very good agreement with the experimental result!
A coincidence?

Second selected issue: Cosmology and scale invariance

The main idea was to generate Newton constant through spontaneous breaking of scale invariance in presence of Gravity (Cooper and Venturi 1981).
As by product, a de Sitter solution was found for flat FLRW space-time.
A general approach (Bamba, Cognola, Odintsov, S.Z. 2014)
Action for a general scalar tensor model

$$I = \int d^x \sqrt{-g} f(R, X, \phi) \quad X = \frac{1}{2}(\partial\phi)^2$$

Eqs. of motion

$$f'_R R_{\mu\nu} - \frac{f}{2} g_{\mu\nu} + (g_{\mu\nu} D^2 - D_\mu D\nu) f'_R + \frac{f'_X}{2} D_\mu D_\nu \phi = 0$$

Look for constant curvature and constant field solutions

$$f'_R R_{\mu\nu} - \frac{f}{2} g_{\mu\nu} = 0 \,, \quad f'_\phi = 0$$

Scale invariant model (Rinaldi, Vanzo 2016) with α, ξ, λ dimensionless constants

$$f = \frac{\alpha}{36} R^2 + \frac{\xi}{6} R \phi^2 + \frac{1}{2} (\partial \phi)^2 - \frac{\lambda}{4} \phi^4$$

The original 1981 Cooper-Venturi model : $\alpha = 0$.
The pure quadratic model $f = R^2$ investigated by the Trento group. The constant curvature solution conditions give

$$R = \frac{3\lambda}{\xi} \phi_0^2 \,, \quad \phi = \phi_0$$

for $\lambda > 0, \xi > 0$ one gets dS solution (Cooper-Venturi 1981).

Note α is not present in the Ricci scalar.
For the pure R^2 dS solution is present with arbitrary Ricci curvature!
Cooper and Venturi investigated approximate solution in presence of matter
With $p = \omega\rho$, they found

$$\frac{\dot{G}}{G} = \frac{1 - 3\omega}{1 + 6\gamma} t:$$

Finally I would like to mention a recent paper written with Gianni and Trento group (Rinaldi, Vanzo, S.Z. and Venturi 2016). The starting point is the Cooper-Venturi action with a one-loop quantum correction in the JF

$$L_J = \sqrt{-g}\left(\frac{\xi}{6}R\phi^2 - \frac{1}{2}(\partial\phi)^2 - \frac{\lambda}{4}\phi^4 - \frac{b}{4}\phi^4\ln(\phi/\mu)\right)$$

Passing to the EF with a field re-definition

$$L_E = \sqrt{-g}\left(\frac{M^2}{2}R - \frac{1}{2}(\partial\phi)^2 - B\phi\right)$$

Slow roll approximation

$$r = \frac{8}{3}\,(1 - n_s)$$

Not so good: $n_s = 0.968$ gives $r = 0.085$, Exp. $r < 0.032$.
For small logarithmic correction and slow roll regime the above model is equivalent to the quasi scale invariant quadratic gravity

$$f(R) = \sqrt{-g}\left(R^2 - \gamma R^2 \ln(\frac{R}{\mu^2})\right)$$

investigated by the Trento Group. Inflationary quasi scale-invariant cosmological attractor have also been investigated

Third selected issue: Quantum gravity in Born-Oppenheimer approximation

Initiated in the seminal paper by Robert Brout 1983
Further several contributions from 1983 up to present, in collaboration with many of his colleagues.
See the next talks!

Bibliography

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Thank you!

A PRESTO GIANNI!