Raffaele (Lele) Tripiccione

1956-2021

A theoretical physicist, a computer scientist and a friend

Lele obtained his master degree in Physics in 1980 and joined the INFN in 1984

That was the period when Nicola Cabibbo,Giorgio Parisi and Giovanni Fiorentini developed the APE Project

Lele joined the APE group and soon became a focal point in the SW design and development.

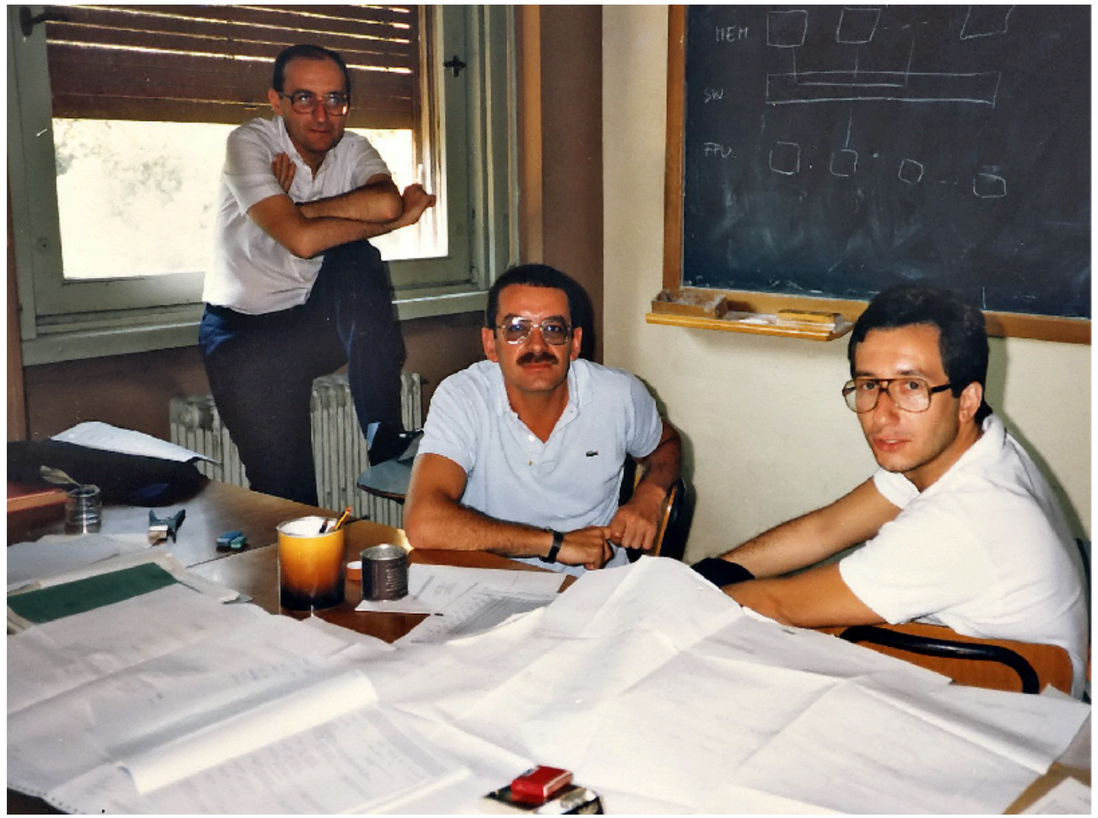
1979: The early pioneers:
the Caltech Ising machine (D. Toussant, G. Fox, C. Seitz)

circa 1985:

APE (16 nodes, 1 Gflops)
Columbia (~ 1 Gflops)
GF11 (IBM / Yorktown)

1990 - 1995:

APE100 (500 – 1000 nodes, 50 – 100 Gflops)
Columbia2 (also about 100 Gflops)



Few words on the APE project

The APE project in Europe

- *Bologna*
- *Ferrara*
- *Pisa*
- *Padova*
- *Roma*
- \+ *Bielefeld - DESY - Orsay - Swansea*

At the beginning of the ’80, computational physics was almost confused with numerical analysis.

Computational physics and theoretical physics were two different things!

But…

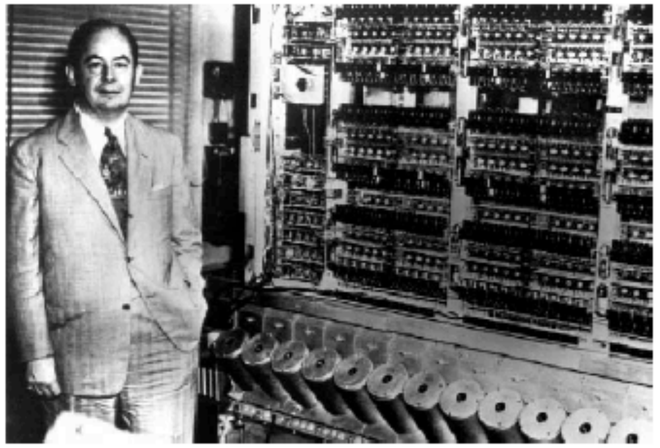
There exist many problems which can be *explored theoretically* only by using very demanding computational tool. QCD is one of this problem.
Lele was a pioneer in this field

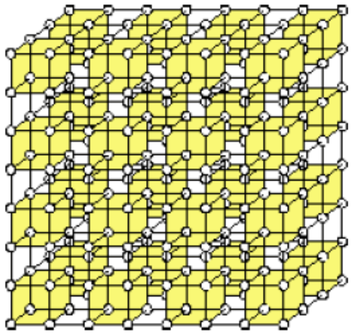
Unfortunately it is not yet known whether the quarks in Quantum Chromodynamics actually form the required bound states. To establish whether these bound states exist one must solve a strong coupling problem and present methods for solving field theories don't work for strong coupling.

K. Wilson, Cargese Lectures, 1976

Slides from Lele presentation in 2010 “Venti anni di calcolo dedicato alla Fisica Teorica”

A historical question:
The guy who invented computer-(models) made his model a physics-friendly beast???





The Answer: NO!

Doing things one after the other (serially)
Keeping data storage and data processing separated (in principle and practice)
are the cornerstones of the famous von Neumann model of computing

Q: So was Von Neumann wrong?

A: No, he was interested in the $P \to 1, \tau \to \infty$ *regime*
today we are approaching the $P \to \infty, \tau \to 0$ *regime .....*

1995 – 2000:
APEmille (1.8 Tflops installed)
QCDSP (1 + 1 Tflops at Columbia & Broohhaven)
CP-PACS (Tsukuba + Hitachi, 600 Gflops)

2000 – 2005:
ApeNEXT (15 Tflops installed)
QCDOC (Columbia + Brookhaven + IBM/Yorktown)

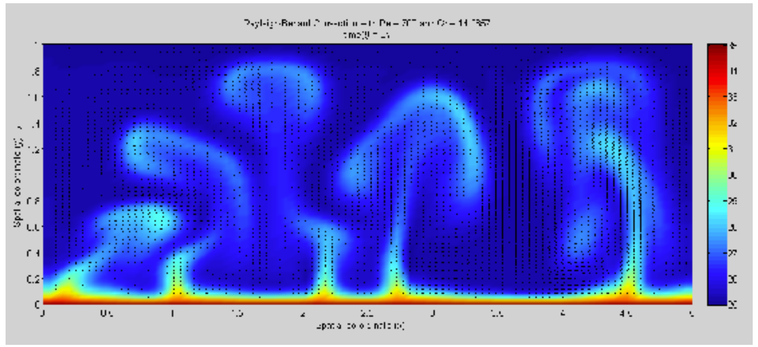
I met Lele at the beginning of 1990 when I gave a talk on computational fluido dynamics and APE

APE was a SIMD machine: single instruction multiple data

Fluid dynamics needs to compute the pressure p by solving the equation $\Delta p = s(\mathbf{r},t)$ at each time step
The solution of this equation requires access to all memory data in the system, not feasible with APE

However, with Sauro Succi we developed a technique where this problem can be avoided, using the Lattice formulation of the Boltzmann Equation. This implies that APE could be used to solve computational fluid dynamics (turbulence).

Few days later, Lele phone me and we start working on the first fluid dynamics simulations with APE



International Journal of Modern Physics C
| Vol. 04, No. 05, pp. 993-1006 (1993)

LBE SIMULATIONS OF RAYLEIGH-BÉNARD CONVECTION ON THE APE100 PARALLEL PROCESSOR

No Access

A. BARTOLONI, C. BATTISTA, S. CABASINO, P. S. PAOLUCCI, J. PECH, R. SARNO,
G. M. TODESCO, M. TORELLI, W. TROSS, P. VICINI, R. BENZI, N. CABIBBO,
F. MASSAIOLI and R. TRIPICCIONE See fewer authors

The APE experience was important in developing new supercomputer facilities

The Blue Gene revolution ...

i) very large 3D meshes of simple, relatively low performance distributed-memory processors (largely inspired by earlier LQCD application-driven number-cruncher)

ii) you better learn to adapt your algos / programs to this specific architecture ...

carries the BigBlue brand...

Physics-friendly at the largest (system) scale

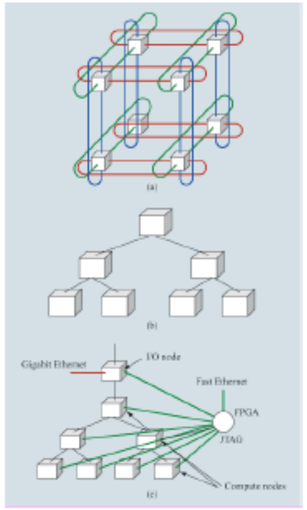


Figure 4

(a) Three-dimensional torus, (b) Global collective network, (c) Blue Gene/L control system network and Gigabit Ethernet networks.

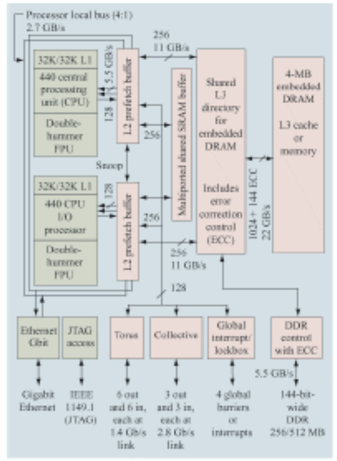


Figure 5

Blue Gene/L compute (BLC) chip architecture. Green shading indicates off-the-shelf cores. ©2002 IEEE. Reprinted with permission from G. Almasi et al., "Cellular Supercomputing with System-on-a-Chip," *Digest of Technical Papers*, 2002 IEEE International Solid-State Circuits Conference.

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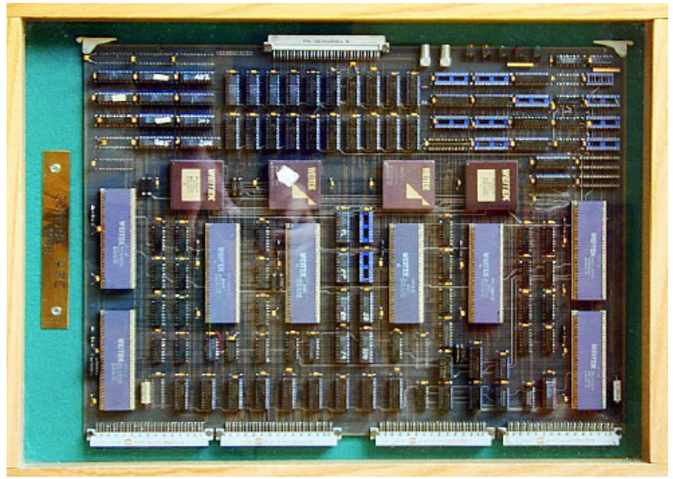
My daddy said we looked ridiculous,
but, boy, we broke some hearts!

(from "I was only joking", Rod Stewart)

APE

Slides from Lele presentation



Computational Physics requires optimisation

↓

Optimization among SW tailored with HW and Numerical Tools

↓

Lele

Lele was **the** expert able to disentangle the advantage of using different tools (SW, HW and languages) in achieving high performance computing for almost all computational problems in physics.

A non trivial physical results from computational physics obtained with Lele

The basic quantity to study in fully developed turbulence is the probability distribution of velocity fluctuations

Following Kolmogorov, one consider the probability distribution

$$P[\delta v(r)] \quad \text{where} \quad \delta v(r) = v(x+r) - v(x)$$

For small values of *r*, we can look at the scaling properties of *δv(r)*:

$$S_p(r) \equiv \langle \delta v(r)^p \rangle \qquad S_p(r) \sim u_0 \left(\frac{r}{L}\right)^{\zeta(p)}$$

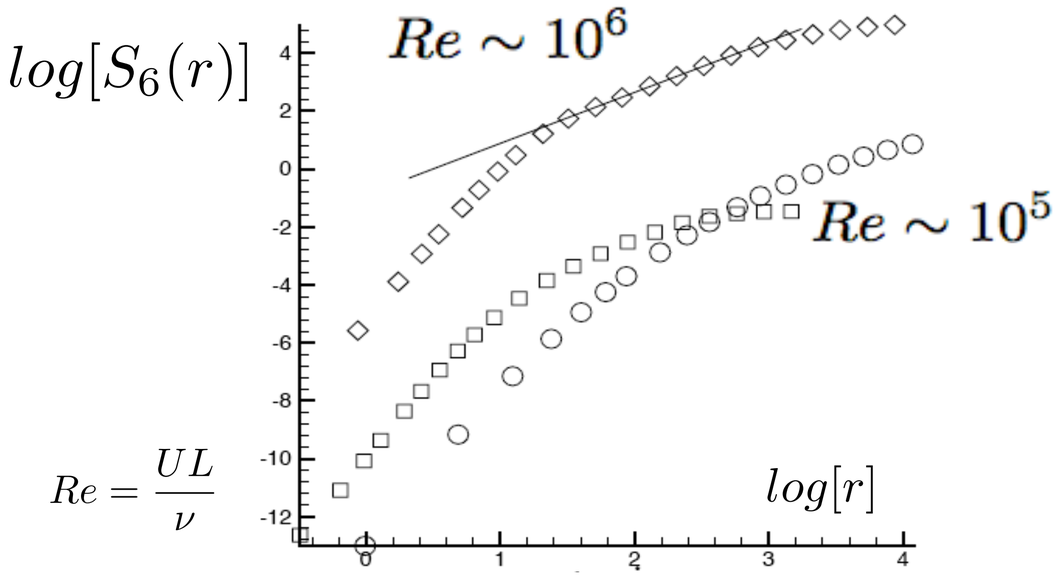
Theoretical we can predict that $\zeta(3)=1$ (Kolmogorov 1941)

It is important to understand if $\zeta(p)$ is a linear or a non linear function of p.

If ζ(p) is a linear function of p, turbulence is self similar.

If ζ(p) is a non linear function of p, turbulence is not self similar and displays anomalous scaling

However scaling exponents are difficult to measure….

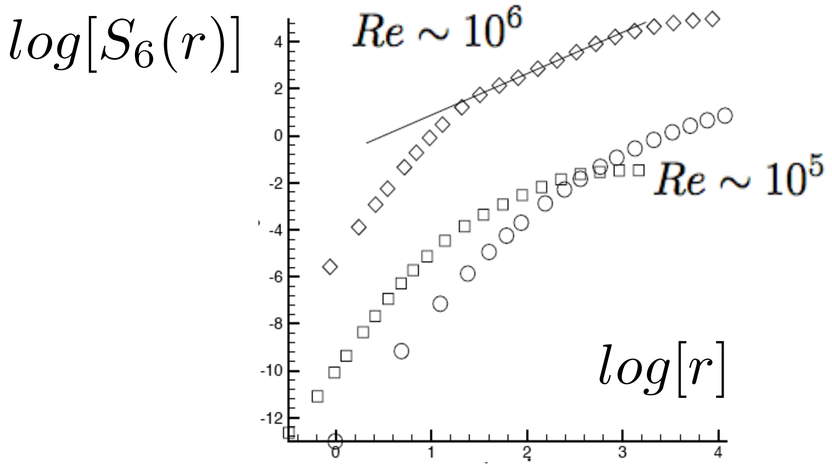


At the time we were working together, numerical simulations with APE allow simulation with Re ~10^4 !!

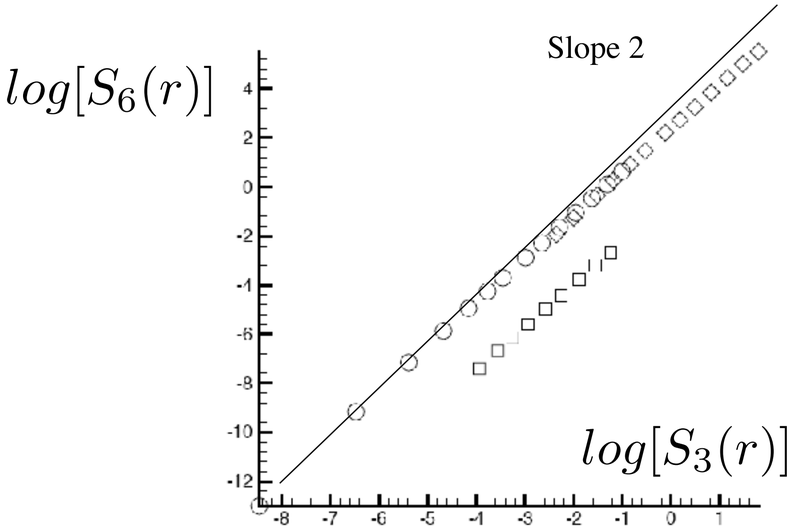
The situation looks hopeless!!

Working with the outcomes from the numerical simulations, Lele and I considered a generalised form of scaling:

$$S_p(r) = A_p S_3(r)^{\zeta(p)}$$



Same data set!



Rapid Communication

Extended self-similarity in turbulent flows

R. Benzi, S. Ciliberto, R. Tripiccione, C. Baudet, F. Massaioli, and S. Succi
Phys. Rev. E **48**, R29(R) – Published 1 July 1993

An article within the collection: PRE Milestones

To check this idea we used the experimental data available in the Lyon wind tunnel

Further developments and research in computational physics.

QPACE: follow up of APE

Janus 1 and 2 for spin glasses

Quantum computing….

SM&FT 2017

Lele own recollection

Vent' anni dopo?

Cosa e' rimasto di tutto questo, vent' anni dopo?

Buone notizie:

Un riconoscimento internazionale della qualita' dei risultati di f fisica resi possibili da queste iniziative

Una generazione di giovani a loro agio tra fisica e computer

Qualche timido approccio allo studio del computer come "sistema fisico"

Good news! International recognition of the scientific results

Vent' anni dopo?

Cosa e' rimasto di tutto questo, vent' anni dopo?

Cattive notizie:

Mentre negli Stati Uniti alcune persone chiave di Columbia University (Al Gara, J. Sexton, P. Boyle) inventavano e costruivano Blue Gene.

Alcuni svariati e svariatamente maldestri tentativi di collaborazione con l' Industria (di cui non parlo in questo intervento) non hanno prodotto nessun risultato significativo.

E' mai possibile, come di un cane --
Che le avventure in questo reame ...

Bad new! No significant development for italian industry

Lele preferite motto

“E' facile, forse anche possibile!” (G. Parisi, circa 1986)

It is easy, may be it is even possible!

This was also Lele’ way to tackle difficult problems and/or situations: lightness as a way to live.

SM&FT 2019: last time I met Lele.