Nimrod Case Studies

Colin Enticott
Slavisa Garic
Tom Peachey

Monash University

Computational Modelling

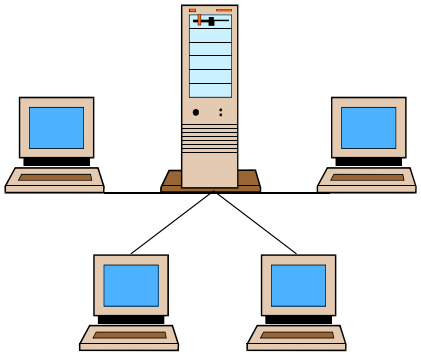
- weather/pollution models
- climate models
- economic models
- drug design
- “in silico” biology
- simulation of materials
- geophysical models
- mechanical design
- electromagnetic models
- experimentation in pure mathematics

Case Studies ...

Public Health Policy

Dr Dinelli Mather
Monash University &
MacFarlane Burnett

Network Simulation

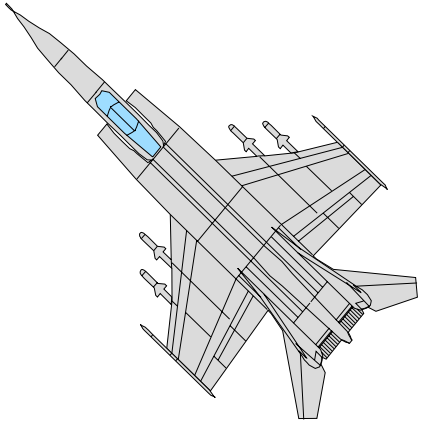


Mahbub Hasan,
Monash University

Neural Network Optimization

Dr Kate Smith,
Monash University

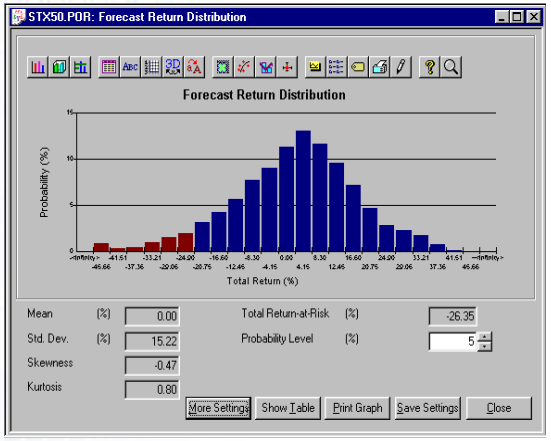
Genetic Algorithms



Dr Shane Dunn,
AMRL, DSTO

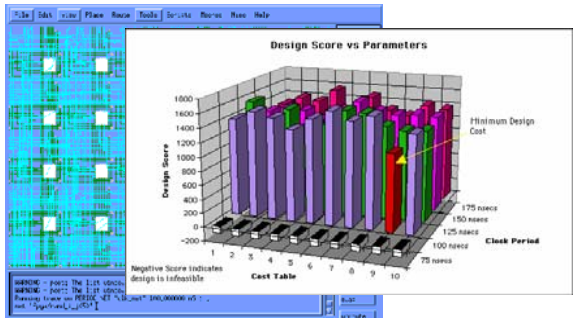
Case Studies ...

Financial Services

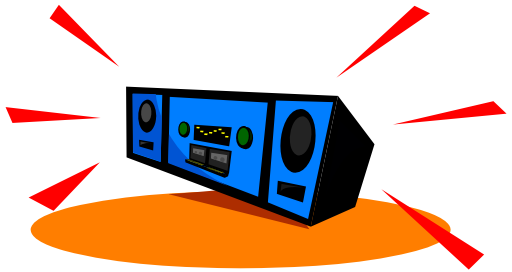


Rendering Movies

CAD Simulation



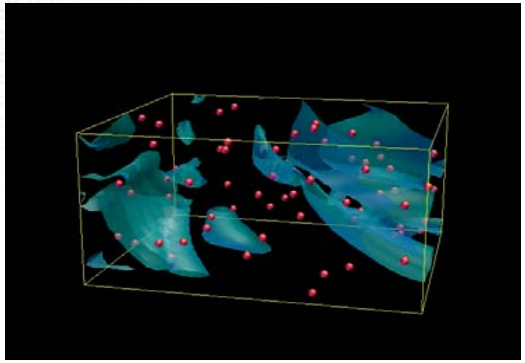
Parallel MP3 Encoder



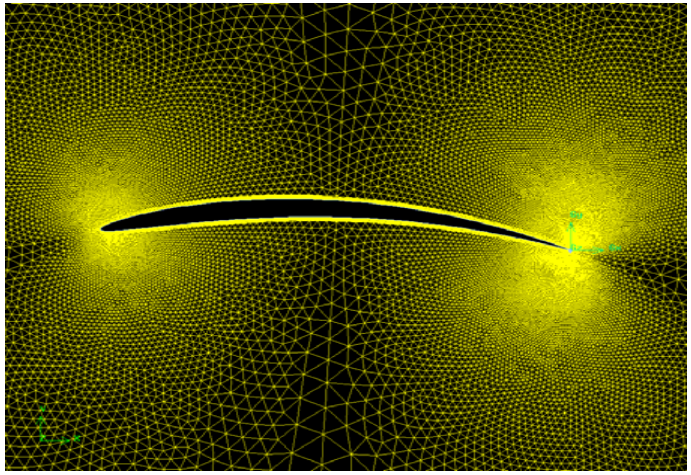
Case Studies ...

Astrophysics

Antenna Design



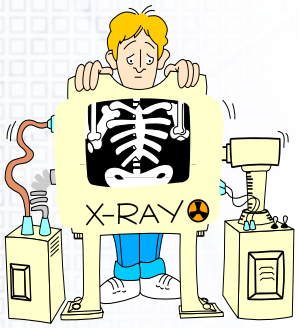
Cattle Tick



Airfoil Design

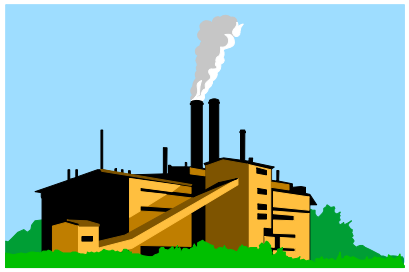
Case Studies ...

Health Standards



Lew Kotler
Australian Radiation Protection and Nuclear Safety Agency

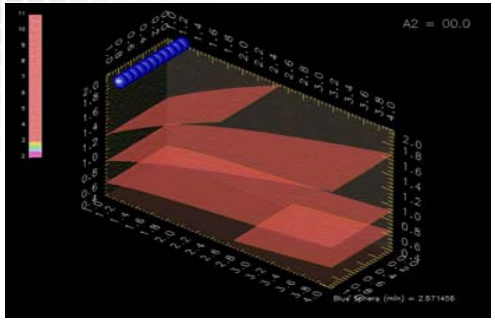
Factory Simulation



John Betts,
Monash University

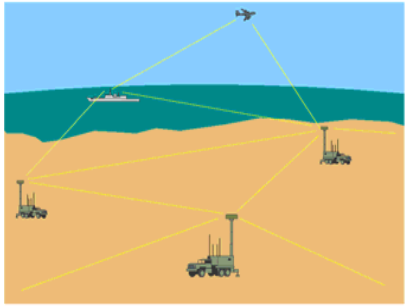
Simulated Annealing Optimization

Marcus Randall,
Bond University



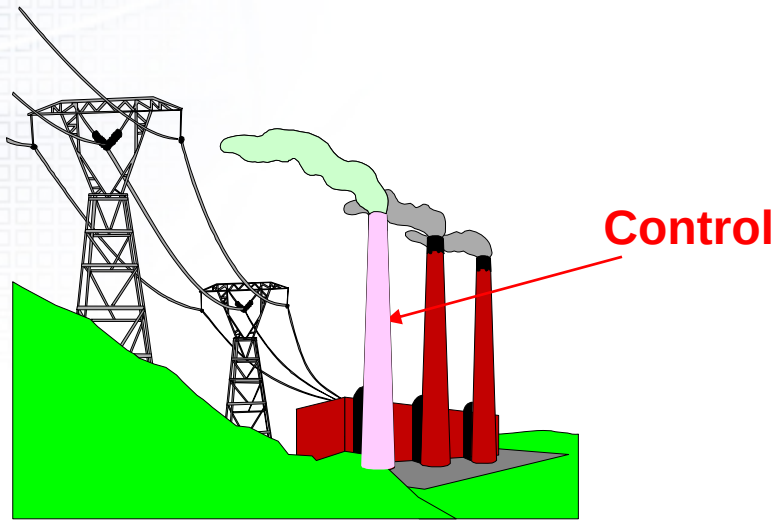
Computational Chemistry

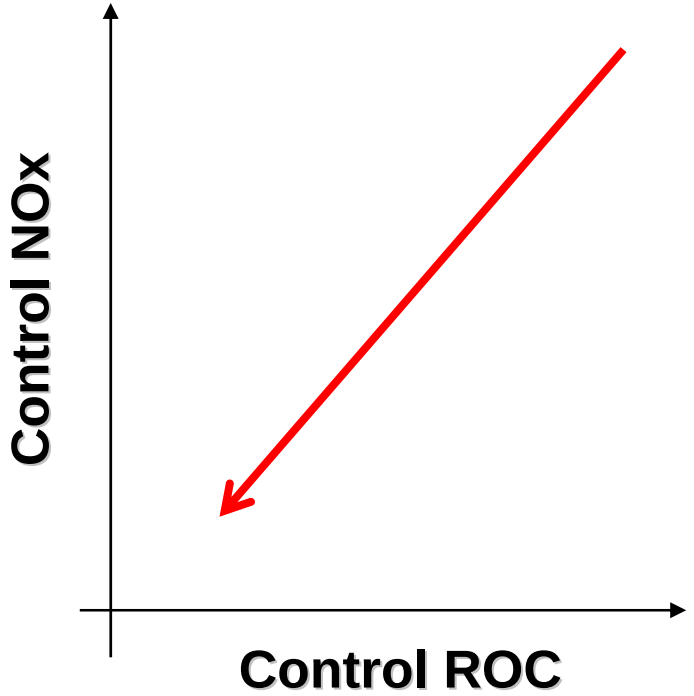
Ad-hoc Wireless



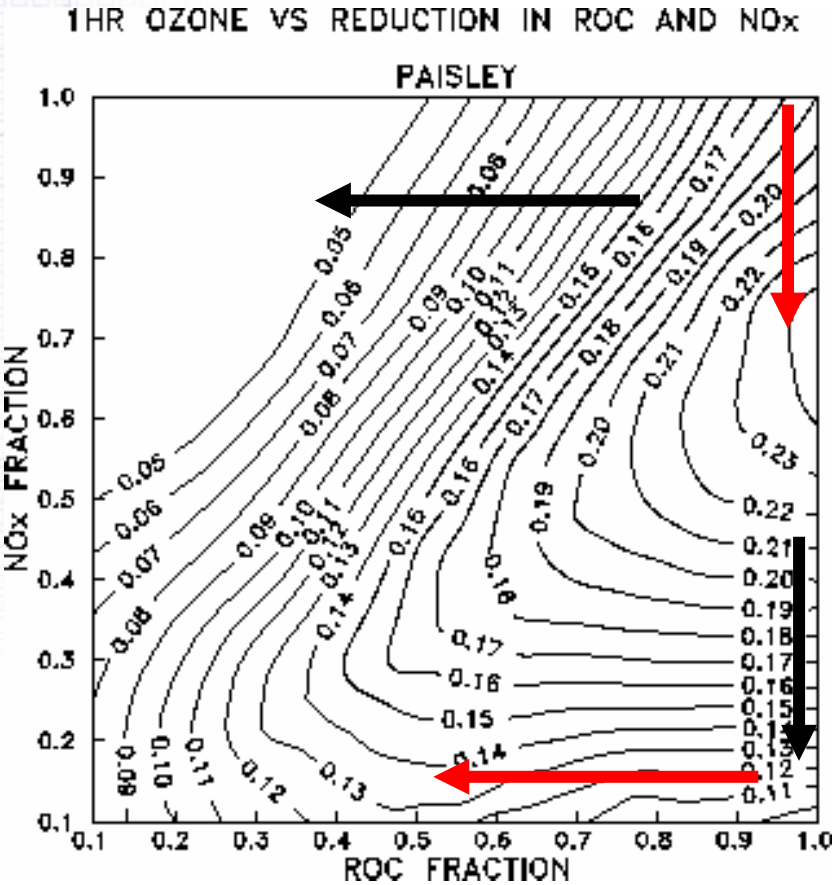
Air pollution modelling circa 1990

- Want to control Ozone
  - What happens if we reduce NOx?
  - What happens if we reduce ROC?





But, ozone chemistry is non-linear



Decreasing NOx increases Ozone

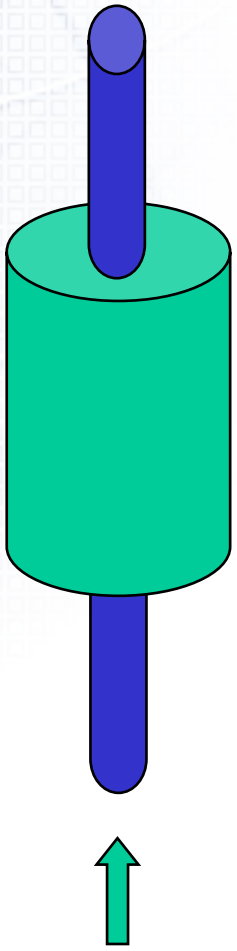
Decreasing ROC decreases Ozone

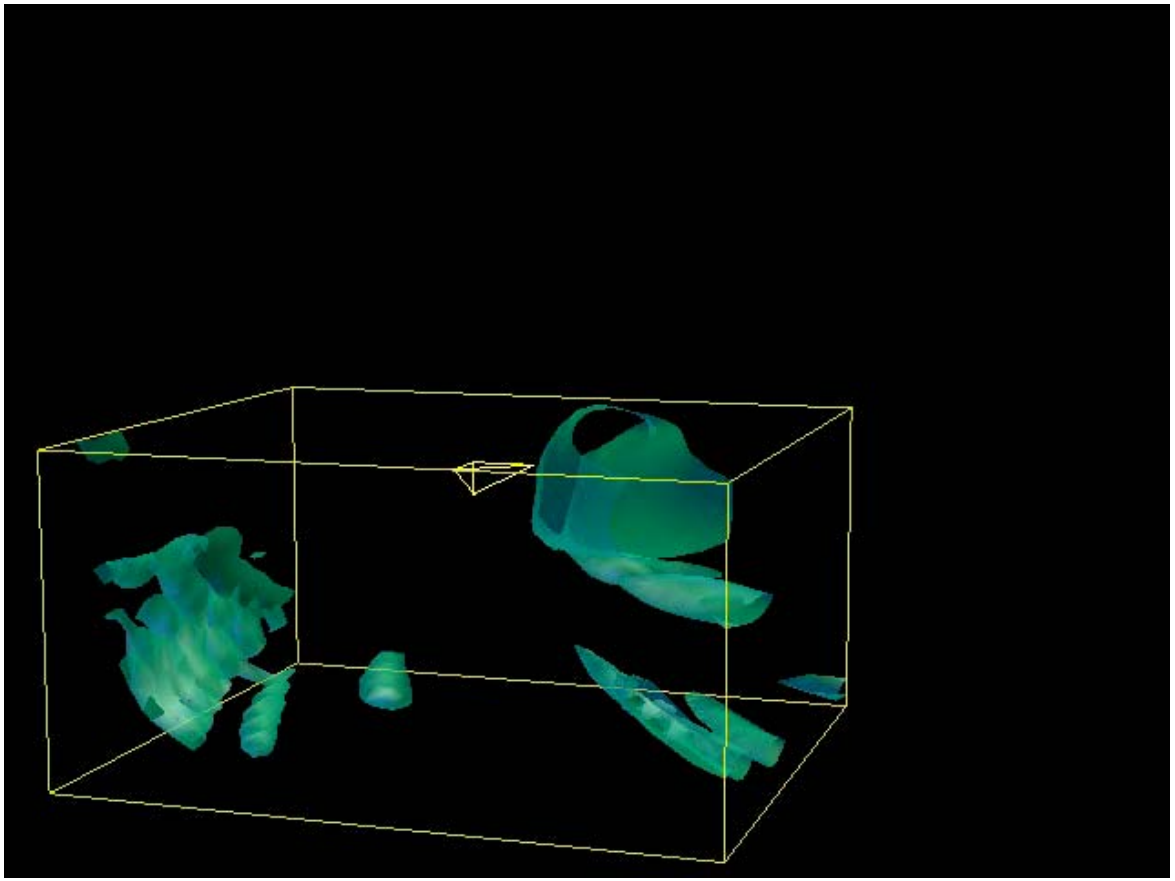
Decreasing NOx decreases Ozone

Decreasing ROC increases Ozone

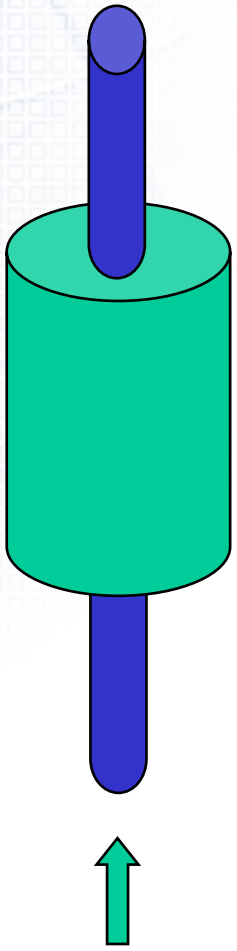
Effect of a ceramic bead on antenna

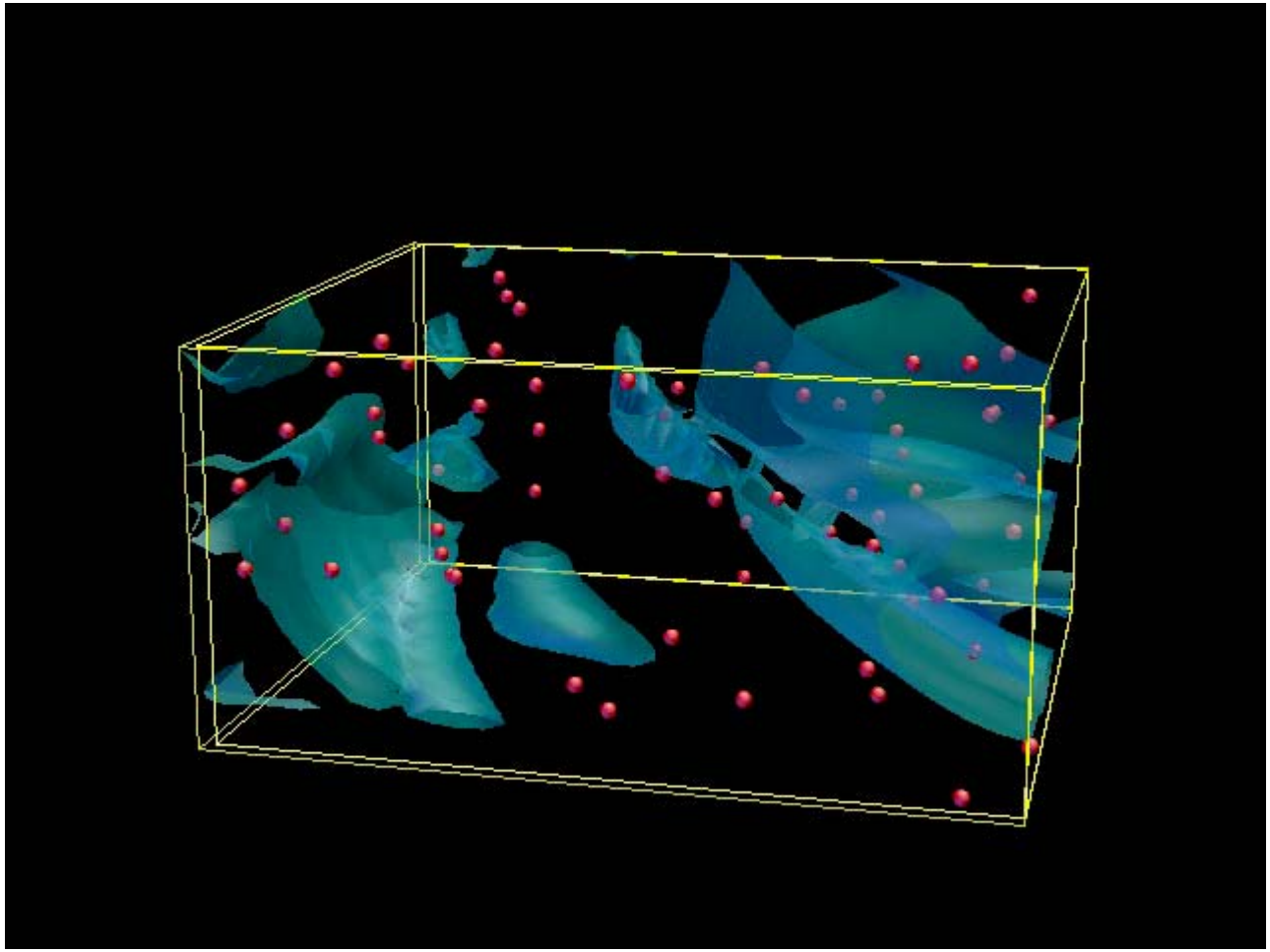
with Andrew Lewis, Griffith University





Divide and conquer on ceramic bead

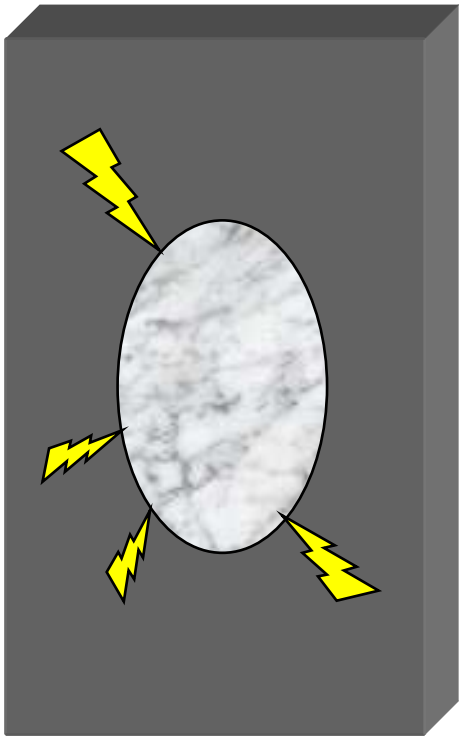




Optimal Fatigue Life of Components

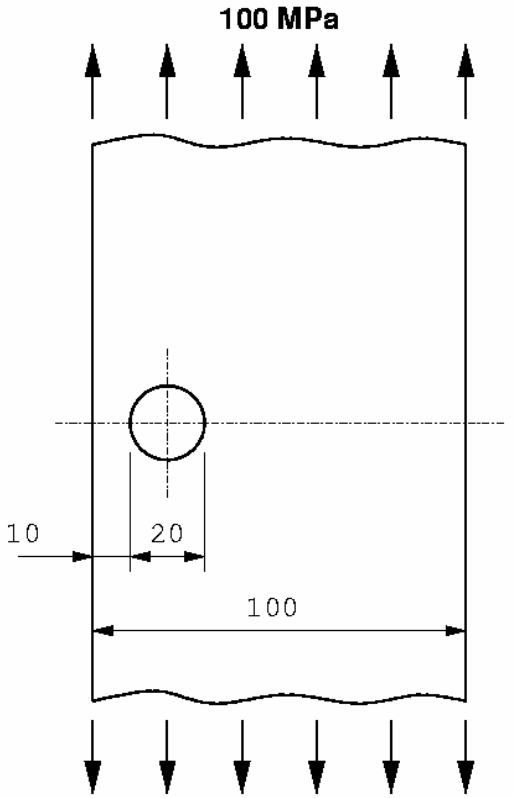
with Rhys Jones, Monash

- Modelling crack propagation in structures



Shape for Optimal Fatigue Life …

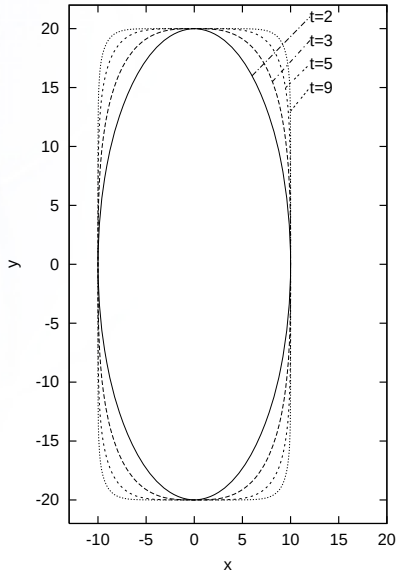
- Design problem - determine the shape of a mechanical component for optimal life.
- Specify the shape of critical surfaces, by
  - control points, or
  - a parameterized family of surfaces.
- Test problem - optimal shape for hole in thin plate under tension.
- Used as a stiffener in an aircraft wing.

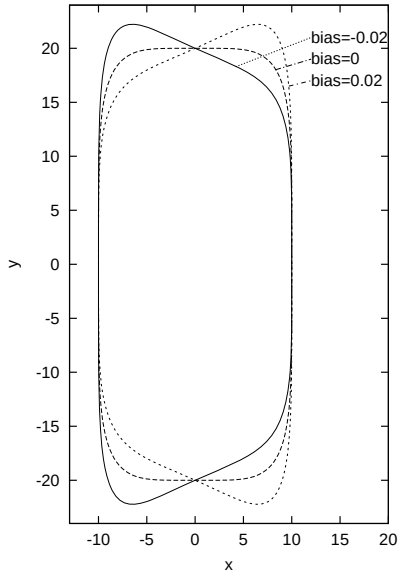


Parameterization of hole shape …

Family of curves

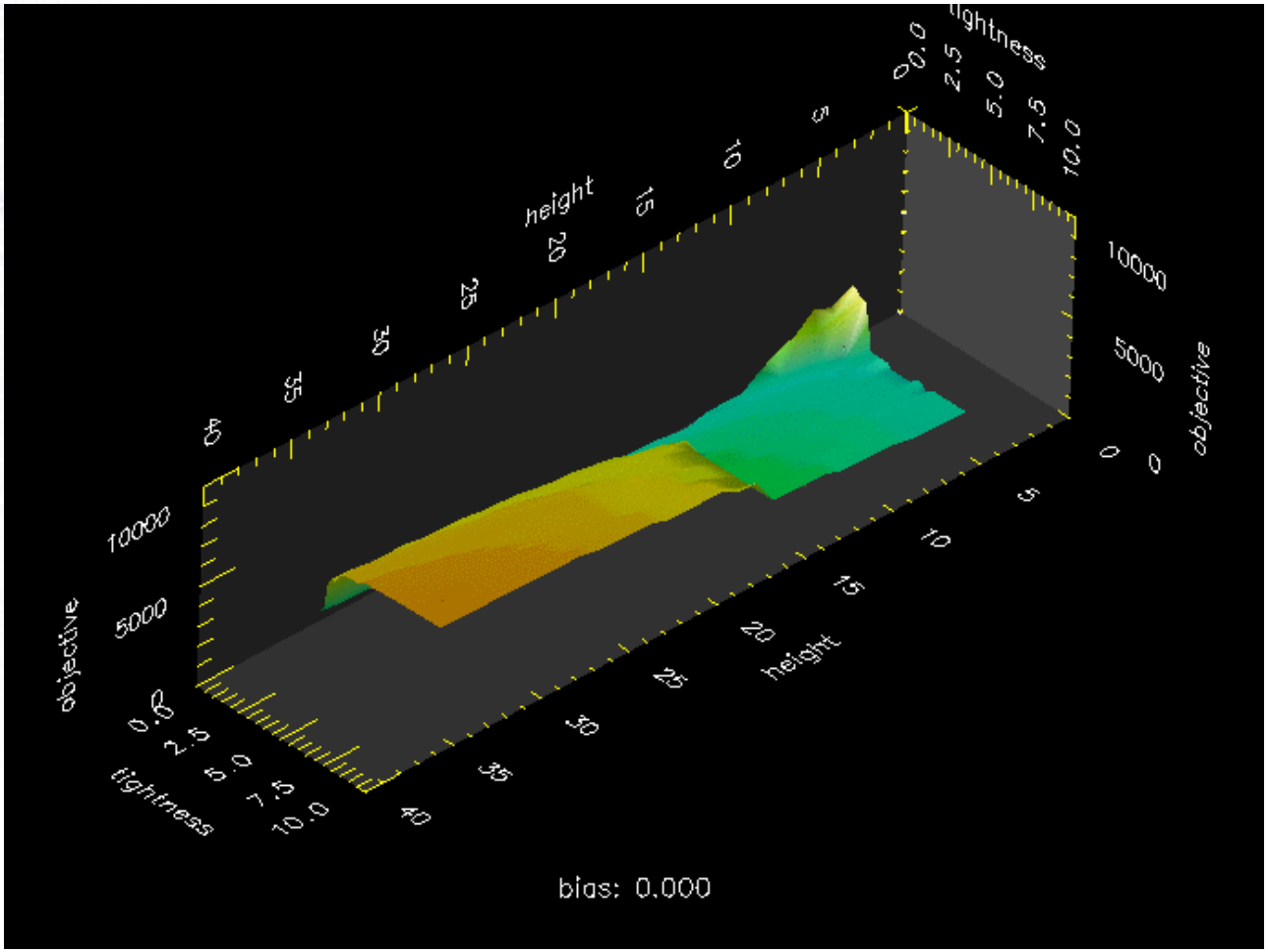
$$\frac{|x-p|^t}{a^t}+\frac{|y-q|^t\, e^{-t\beta(x-p)}}{b^t}=1$$



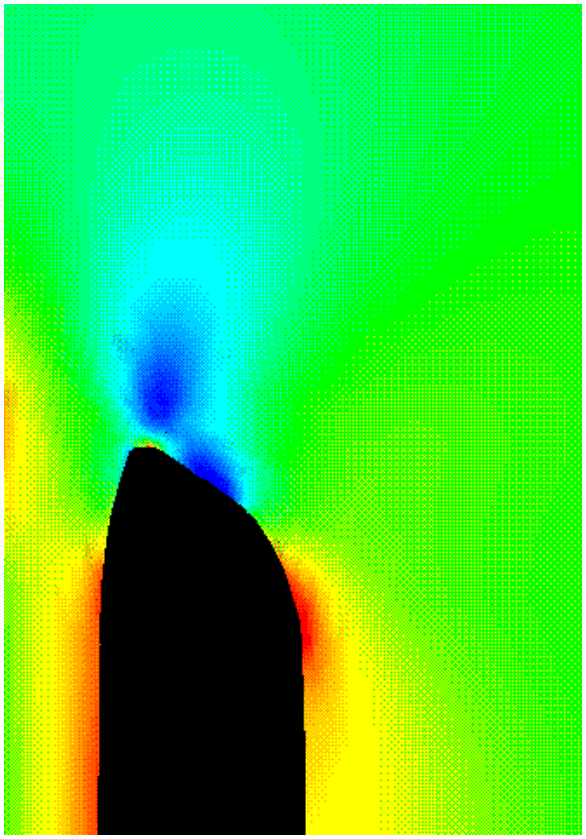


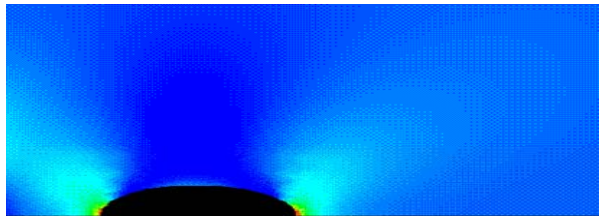
Fix p, q and a. Optimize over b, t and β.

Results of parameter sweep …



Stress Diagrams for Local Optima





Best Constant in the Hilbert Inequality

Suppose $p > 1$, $p' = p/(p-1)$, $1/p' < \lambda \leq 1$, $r = p/(p\lambda - p + 1)$, *and* $f \in L_p$, *then for*

$$F(v) = \int_0^\infty \frac{f(u)}{(u+v)^\lambda}\, du, \qquad (1)$$

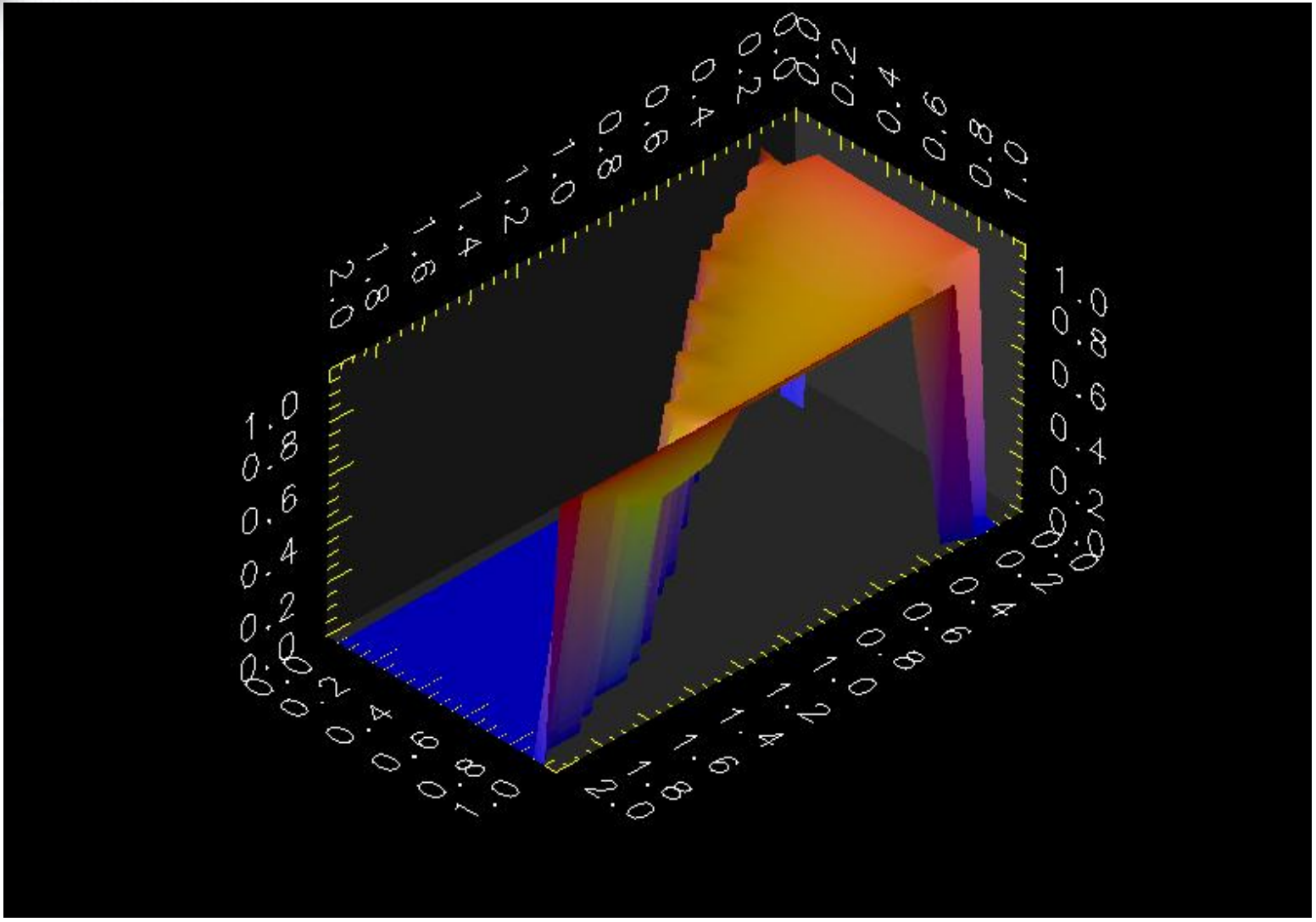
$$\|F\|_r \leq C\|f\|_p$$

where C *depends on* p *and* λ *only.*

$$\|F\|_r = \left[\int_0^\infty F^r(x)\, dx\right]^{1/r}$$

$$\|f\|_p = \left[\int_0^\infty f^p(x)\, dx\right]^{1/p}$$

Results of Multiple Optimizations



Simulation of Meteorite Accretion

Dr Kurt Liffman

Centre for Stellar and Planetary Astrophysics (CSPA) at Monash University

http://www.maths.monash.edu.au/astro/

- “The code models the early solar system, where the protoSun is surrounded by an accretion disc, which we call the solar nebula…”
- We will executes this program about 10,000 times exploring about five million particles

Plan file for meteorite simulation

```
parameter input_seed integer random from 1 to 1000000 points 2000;

task main
    copy p.x node:p.x
    copy projectile.input.sub node:projectile.input.sub
    copy projectile.x node:projectile.x
    substitute projectile.input.sub projectile.input
    node:execute ./p.x
    copy node:distance.out distance.out.$input_seed
    copy node:temperature.out temperature.out.$input_seed
    copy node:error.out error.out.$input_seed
    copy node:disk.out disk.out.$input_seed
    copy node:density.out density.out.$input_seed
    copy node:initial_particle.out initial_particle.out.$input_seed
    copy node:ejected_particle.out ejected_particle.out.$input_seed
    copy node:stopped_particle.out stopped_particle.out.$input_seed
endtask
```

Air Traffic Control Simulations

with Peter Lindsay, UQ