A frequency dynamics algorithm for GW-bursts

ASIS

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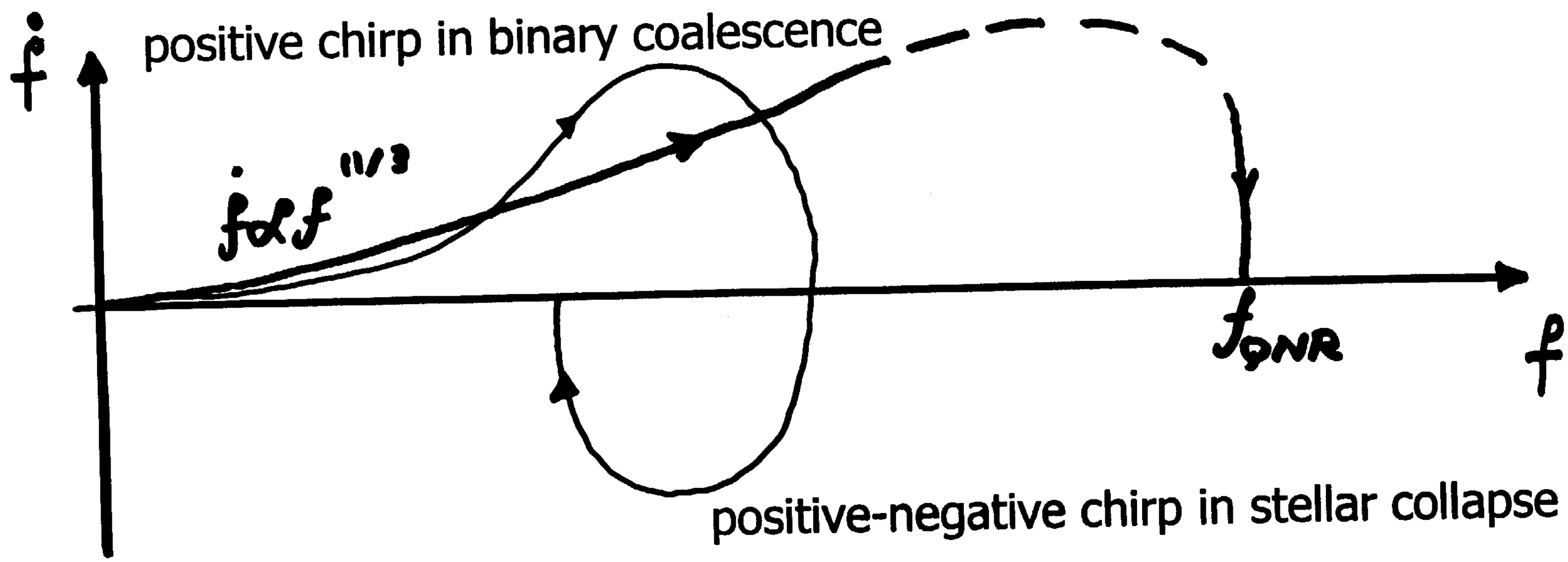
Astrophysical GW sources

- BH/NS-binaries
- Collapsars
- GRB progenitors/GRBs
- new sources by serendipity

An $\dot{f}(f)$-diagram



-> extract trajectories in the $\dot{f}(f)$-plane

A zero-crossing algorithm

- Model: $X(t)=A(t)\cos(2\pi\,\Phi(t))+\sigma N(t)$

  $\Phi(t)=c[1-(1-t)^{5/8}+p(1-(1-t)^{3/8})]$

  $p=0.6038$, $A=(1-t)^{-1/4}$ (1PN)
- Detect zeros (suppress amplitude)
- Linear regression on subintervals:

  $f(t) = \alpha+\beta t \quad (t_i<t<t_{i+1})$

  (α,β) estimates of pts in the plane

Noise dependence

- Instrumental 40m LIGO noise
- White Gaussian noise

  n(f) from 400 to 200 in simulated chirp

  LIGO noise is red: fewer false crossings

cf. Gaussian w/ autocorrelation ρ has

\# zero-crossings

$$\frac{N-1}{2}\left(1 - \frac{2}{\pi}\tan^{-1}\frac{\rho}{\sqrt{1-\rho^2}}\right)$$

$\dot{f}(f)$ - diagram of simulated binary coalescence (S-to-noise = 4) *

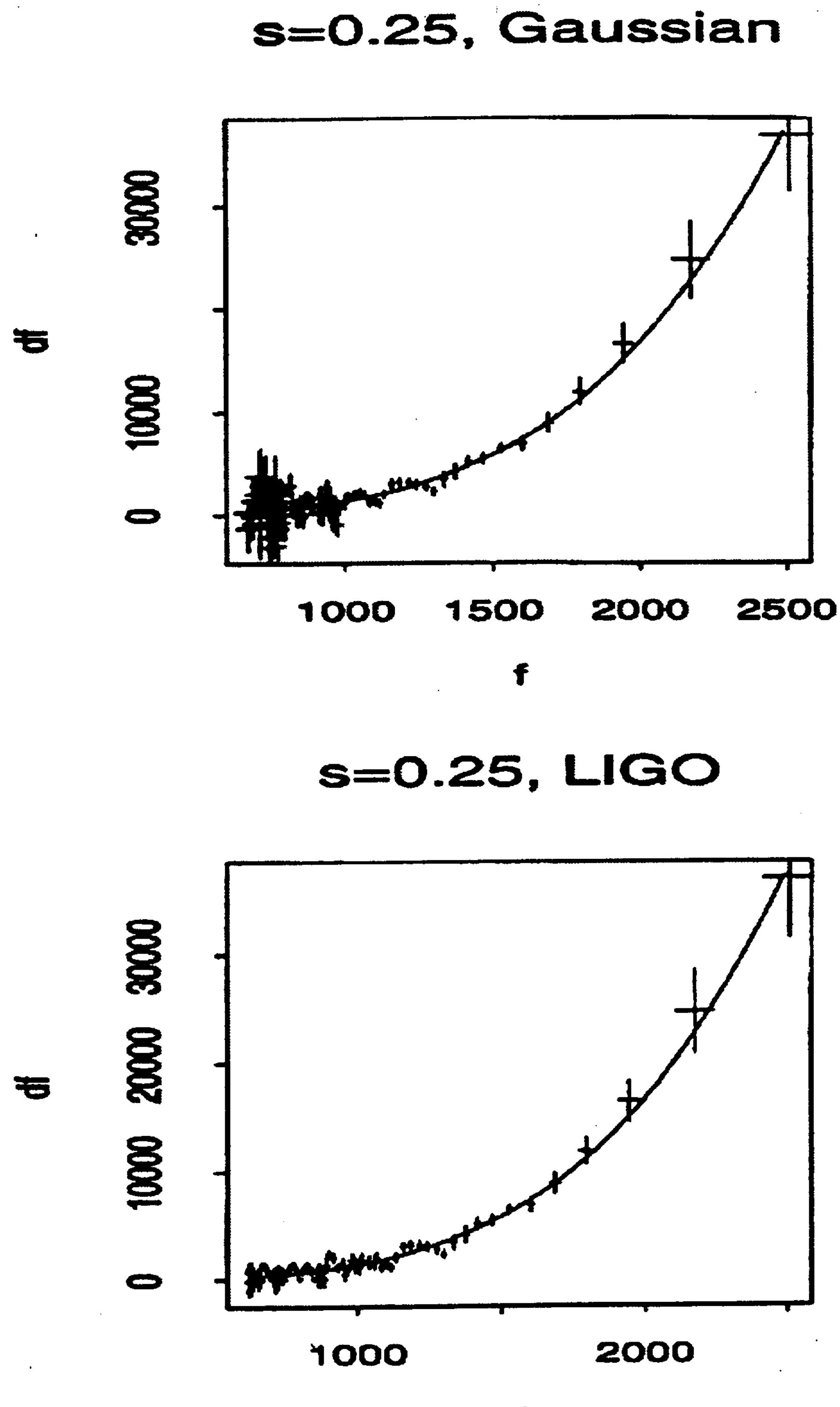


Figure 1.

* under review by LSC

Comparison w/ matched filtering

- Compare model-independence of algorithm with sensitivity of matched filtering to model-imperfections
- Experiment:

  true signal = 1PN chirp (p=0.6038)

  assumed signal = Newtonian chirp (p=0)

to simulate e.g. unknown finite size effects

Experiments on model-independence

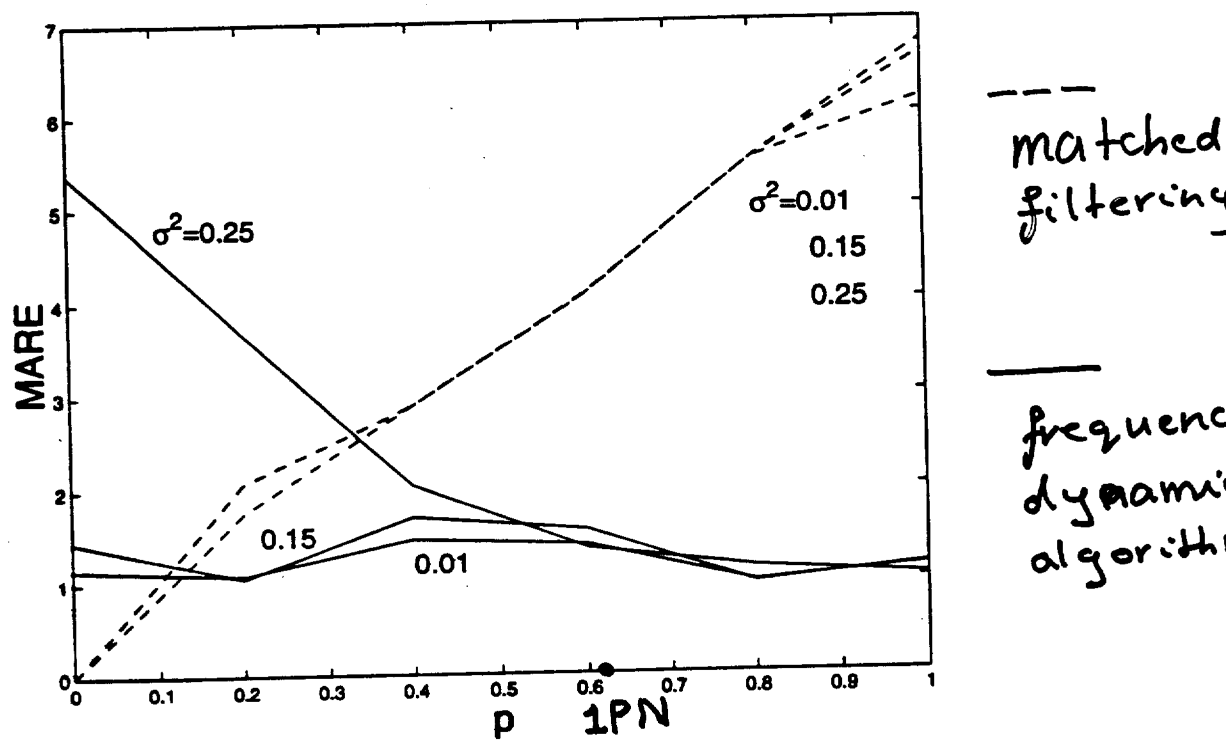


Figure 2.

- $$MARE = \frac{100}{N} \sum_{1}^{N} \frac{|\hat{f}(t_i) - f(t_i)|}{f(t_i)}$$

- Monte Carlo study

Conclusions and...

- Binary chirp $\dot{f} \propto f^{a+1/3}$, L_{GW} f^a (a_{GR}=10/3)
- Initial chirp/$\dot{f} \propto -f^b$ by L_{GW} from a single star

-> *distinctive trajectories in $\dot{f}(f)$-diagram*

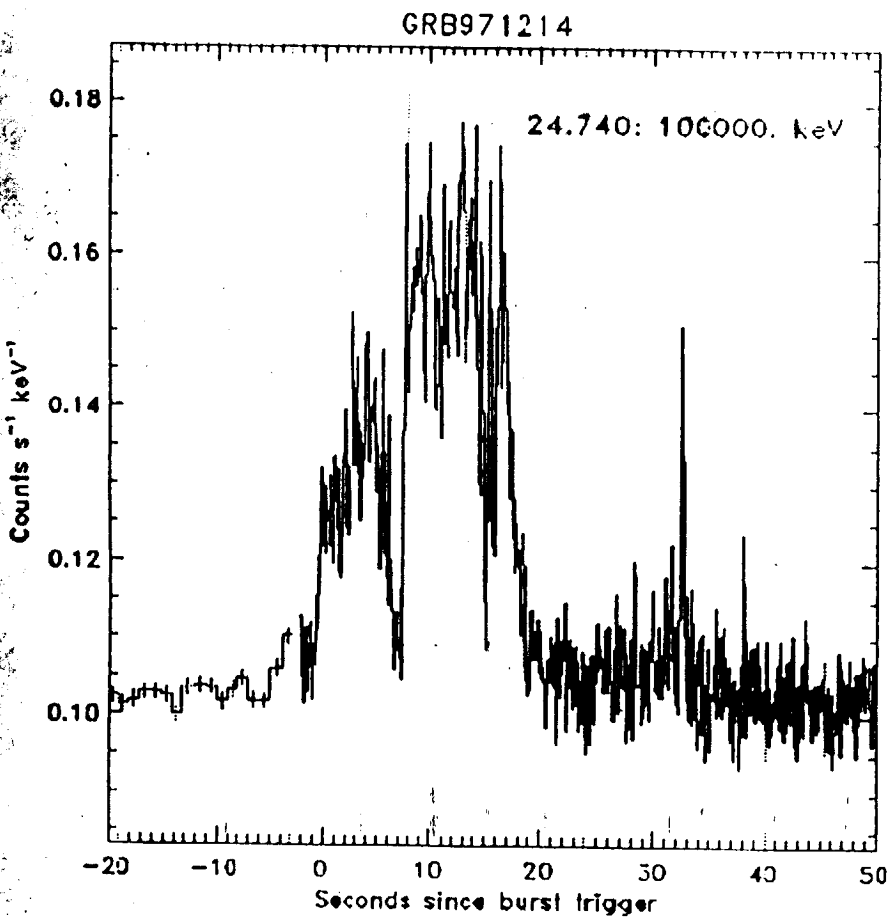
- Frequency dynamics algorithm more accurate

with LIGO-noise than white Gaussian
than matched filtering w/ model-imperfections

...Outlook for LIGO II

- Multi-window campaigns to detect GRB/GW/RB associations in long GRBs

Observations



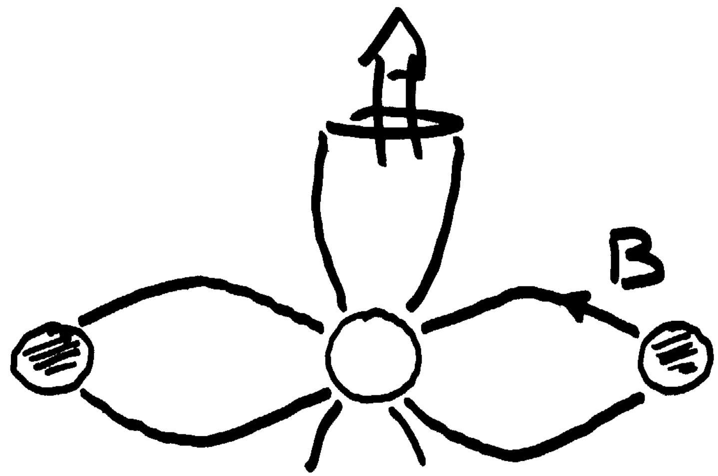
- Cosmological
- $\alpha = G\Delta E/c^5\delta t = 10^{-4\ -2}$
- $<V/V_{max}> = 0.334$
- Intermittent
- Non-thermal
- νF_ν at ~ 1MeV
- $E \sim 10^{51-54}$

Spin-powered GRBs

- $E_{rotation} > E_{NS}$
- Long GRBs, set by spin-down time
- Jet formation along open field-lines

Black hole-torus systems*

- Collapsars or binary coalescence BH/NS



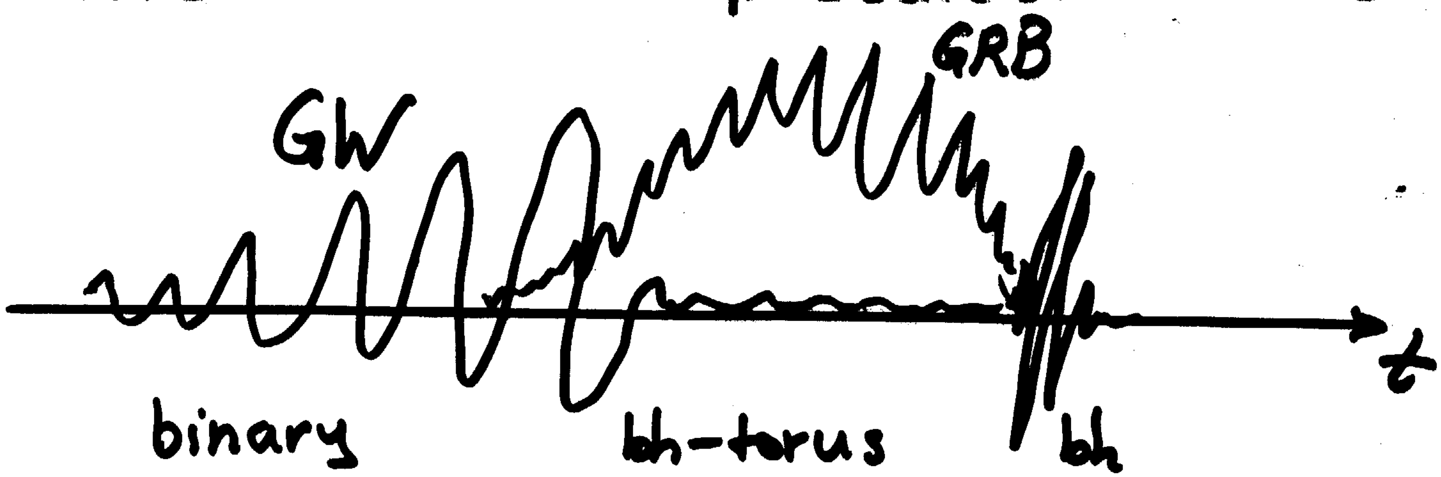
- Spin-powered GRBs in black hole-torus state

* Paczynski '91
van Putten, Science, '99
van Putten, PRL, '00 (in press)

Observational tests

The black-hole torus model of long GRBs predicts

- Anti-correlated GW-GRB emissions
- correlated GW-RB precursor emissions



Note 1, Linda Turner, 05/09/00 09:10:19 AM
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