National Aeronautics and
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Problem: Searching for long-lived, weak chirps in noise

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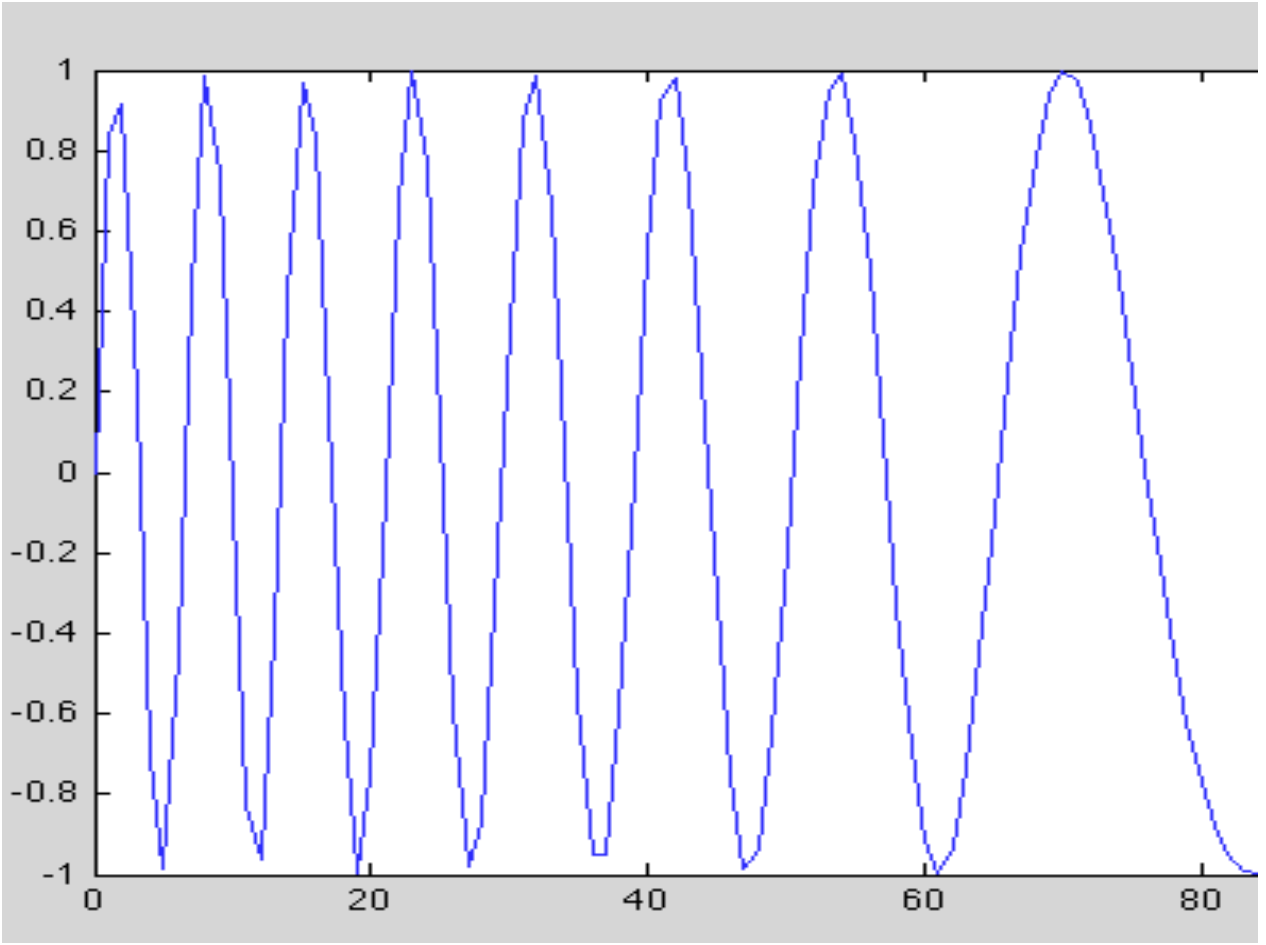
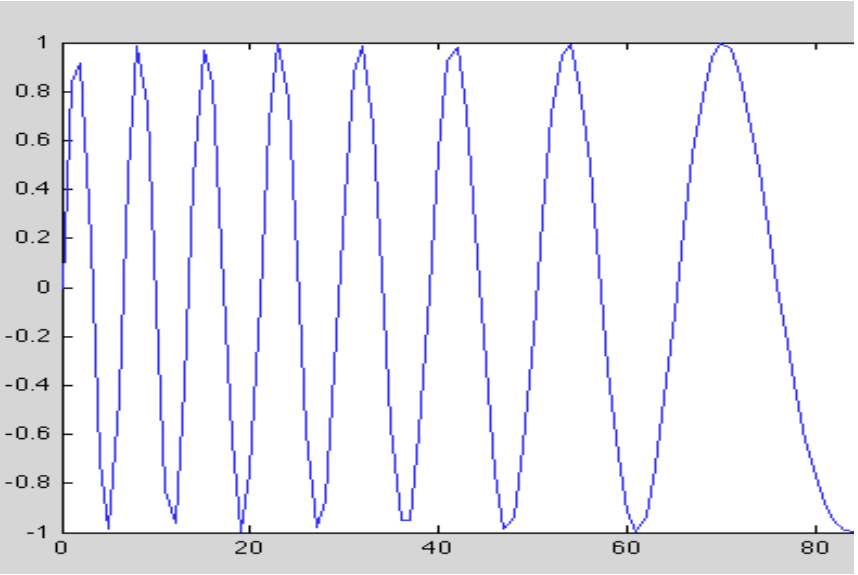
h(t)

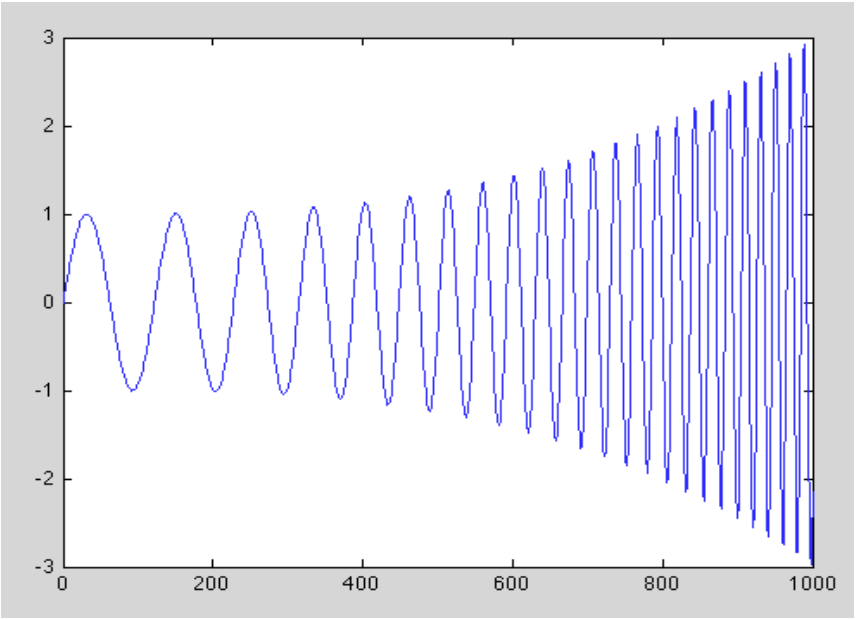


t→

Examples from gravitational-wave searches

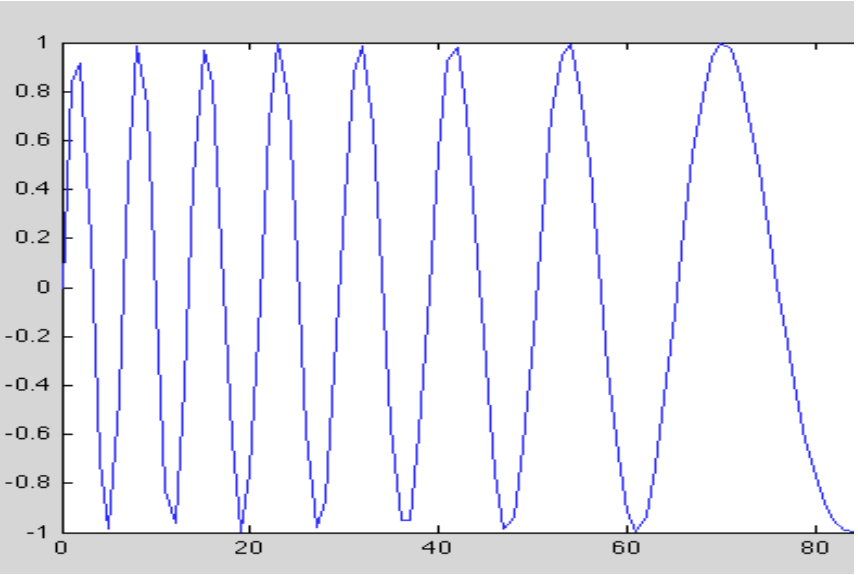


GW source: rapidly rotating neutron star with small, quadrupolar "mountain" (order 1 cm high)



GW source: inspiraling binary of two black holes

“Gravitational-wave pulsar” searches



Order of magnitude values

$$f \sim 300\ Hz$$

$$T_{obs} \sim 1\,yr \sim 3e7\,s$$

$$\Rightarrow N_{cyc} \sim 10^{10}$$

$$\frac{h}{n} \sim 10^{-4}$$ at any instant, so with matched filtering:

$$SNR \sim \frac{h}{n}\sqrt{N_{cyc}} \sim 10$$

Actually, blind all-sky searches are looking for signals with SNR ~ 20-25.

Parameter space and # of Templates

- Typically ~5-6 parameters: $\theta, \varphi, f_0, \dot{f}_0, \ddot{f}_0$

(plus 4 others that are trivially searched over)

For all-sky searches for unknown, fast, young pulsar, number of templates to cover search space is

$$\sim 10^{22}$$

This is # of FFTs

Comments

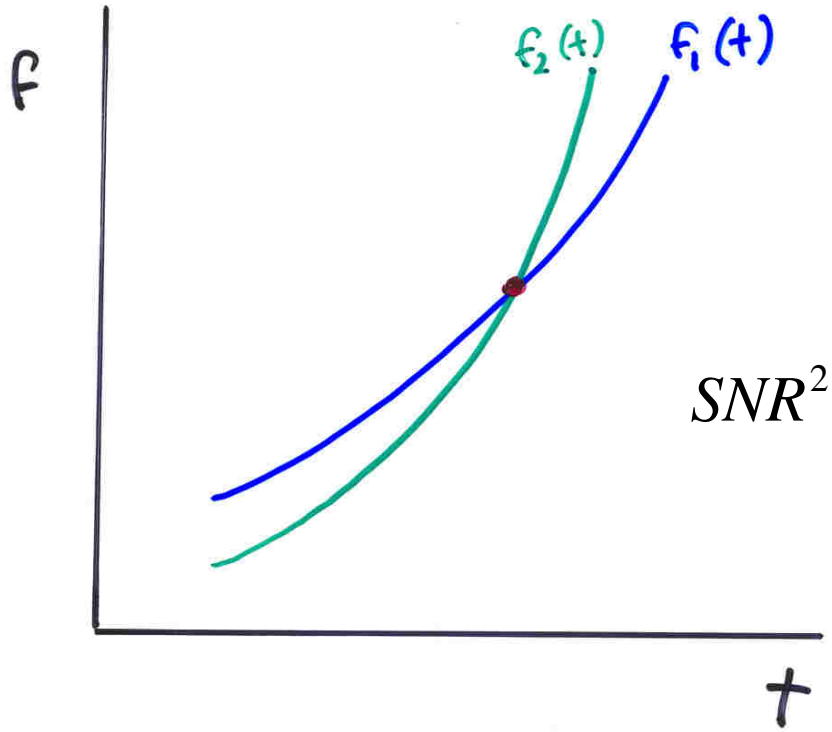
- To my knowledge, best current methods are semi-coherent and hierarchical (see talk by J. Rice)

- Observation: when template has decent (not great) overlap with imbedded signal, most of the SNR is “localized” in t-f space.

How 2 different chirping waveforms "interfere with" each other:

$\int h_1(t) h_2(t) dt$ integral dominated by contribution

from short time around crossing of $f_1(t)$ and $f_2(t)$



$$SNR^2 \propto (\delta \dot{f})^{-1/2}$$

t-f tracks for 2 merging NS binaries at different z

1st (simpler) version of proposed problem

1) Parameters are just: $f_0 , \dot{f}_0 , \ddot{f}_0 , \dddot{f}_0$

with

$$h = A \sin\varphi(t) \qquad \varphi(t) = f_0\, t + \frac{1}{2}\dot{f}\, t^2 + \frac{1}{6}\ddot{f}_0\, t^3 + \frac{1}{24}\dddot{f}_0\, t^4$$

and A , T_{obs} adjusted to make simplest (grid of templates) matched-filtering search intractable.

2nd (harder) version of proposed problem

1) Few Parameters (~5): θ^i

with

$$h = A \sin 2\pi \int f(t')\, dt' \qquad \frac{df}{dt} = F(f, \theta^i)$$

$$A = A(t, f(t), \theta^i)$$

with both f, A slowly varying, and T_{obs} adjusted to make simplest (grid of templates) matched-filtering search intractable.