

USCIPI REPORT #192

**Moving-Average-System Identification Using
High-Order Spectra: A Simulation Comparison
of Four Methods**

by

Wendy Huang and Jerry M. Mendel

October 1991

**Signal and Image Processing Institute
UNIVERSITY OF SOUTHERN CALIFORNIA
Department of Electrical Engineering-Systems
3740 McClintock Avenue, Room 404
Los Angeles, CA 90089-2564 U.S.A.**

Abstract

Four methods of identification of nonminimum phase systems with finite impulse response are compared in this project.

Via Monte Carlo simulation, the following four methods are compared:

- (1) GM+T method - Giannakis and Mendel
- (2) Bicepstrum method - Pan and Nikias
- (3) MU method - Matsuoka and Ulrych
- (4) RG method - Rangoussi and Giannakis

Different zero locations, noise types, signal-to-noise ratios and data lengths, resulted in 48 cases. Zeros move close to the unit circle with one located inside it and the other one located outside it. Additive noise is Gaussian, white or colored. Signals are non-Gaussian distributed.

The simulation study suggests that estimation of the IR coefficients, the bicepstrum method is the preferred method. GM+T method shows very good stability at estimating the magnitude of IR coefficients. Both MU and RG methods are stable at estimating the phase of IR coefficients, but poor at estimating the magnitude.

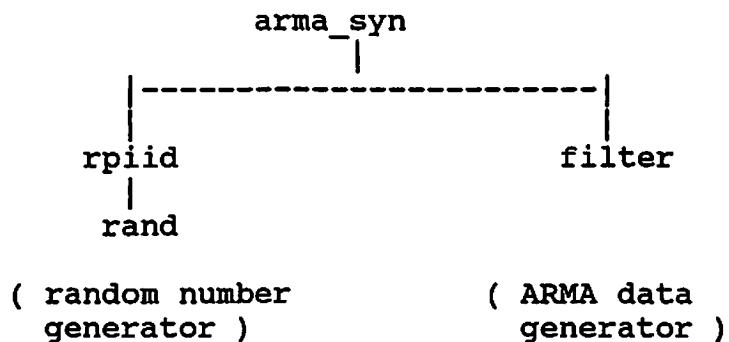
Contents

	page
Abstract	i
I. Program analysis of the four methods	1
A. GM+T method	1
B. Bicepstrum method	2
C. MU method	2
D. RG method	3
II. Simulations	4
A. Input cases	4
B. Parameters setting table	5
C. Output figures and data	6
III. Discussion	10
A. Compare output by data length	10
B. Compare output by zero's location	10
C. Compare output by snr	11
D. Compare output by noise type	11
IV. Conclusion	12
Reference	13
Appendix	14-61

I. Program analysis of the four methods

Those programs used for GM+T, bicepstrum and MU algorithms are functions in the United Signals & Systems, Inc.'s Hi-Spec Computer Software . RG method's program is supplied by Dr. Giannakis.

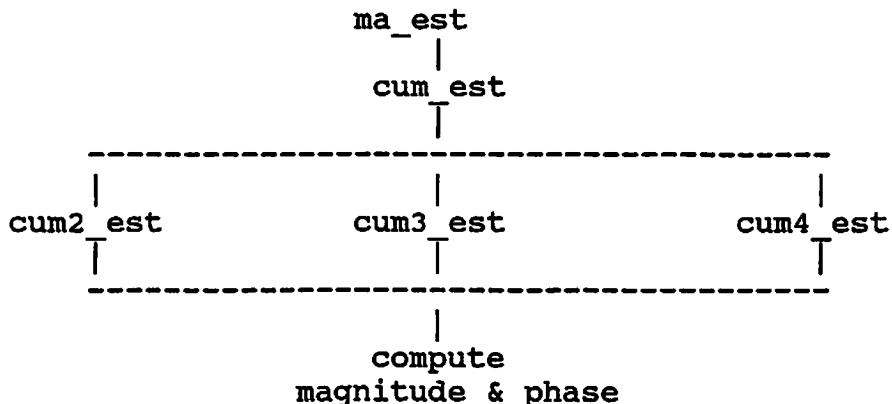
The program, arma_syn, used for generating MA model non-Gaussian, non-linear phase signals and generating the white or colored Gaussian noise is one of Hi-spec's function also.



This program has the capability to generate AR, MA, ARMA, and white or colored Gaussian data by inputting correct parameters. The input data table will be described in the next section.

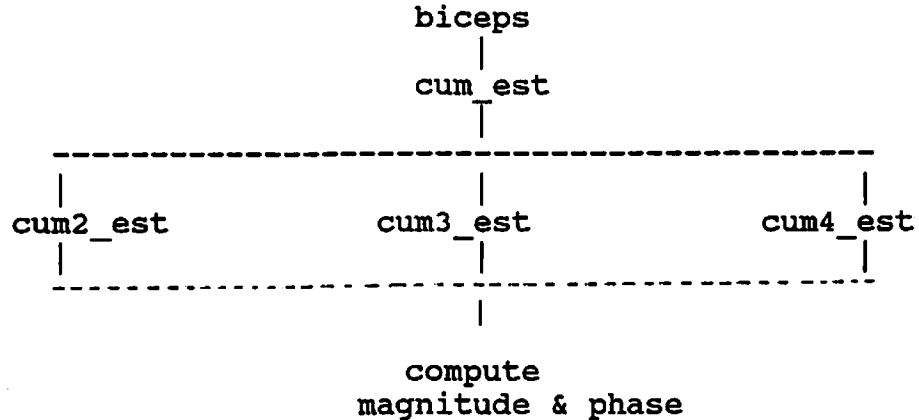
A. GM+T method

After data for each testing case have been generated, we call ma_est to estimate the impulse response and its magnitude and phase for each case.



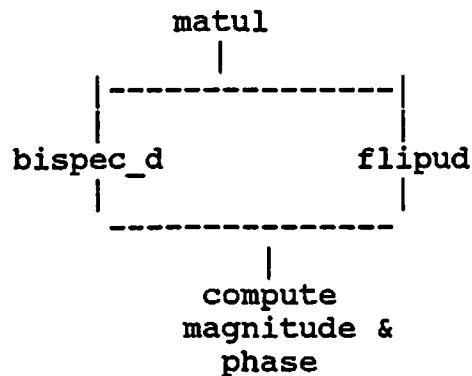
B. Bicepstrum method

After data for each testing case have been generated, we call biceps to estimate the impulse response and then compute the magnitude and phase for each case.



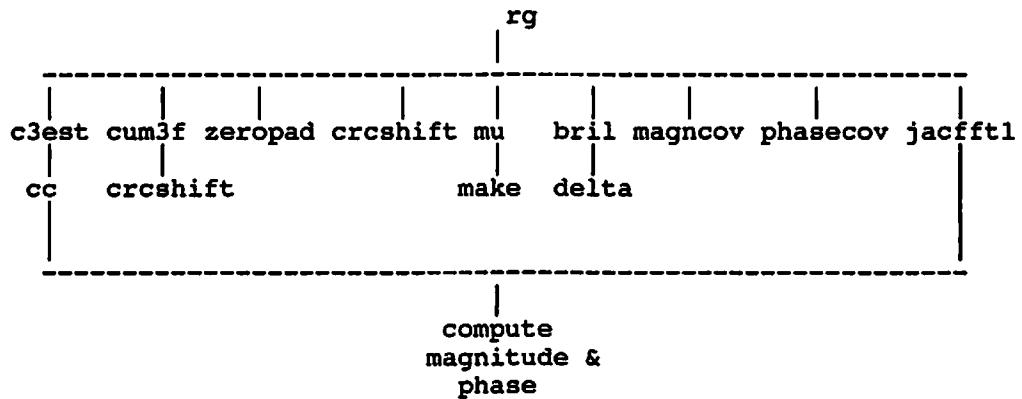
C. MU method

After data for each testing case have been generated, we call matul to estimate the impulse response and then compute the magnitude and phase for each case.



D. RG method

After data for each testing case have been generated, we call Dr. Giannakis's program -- rg to estimate impulse response and compute its magnitude and phase for each case.



II. Simulations

A. Input cases

For each of the four methods, we have the following parameters :

- (1) data length - 2 lengths: 128x4 and 128x8
- (2) zeros locations - 4 locations: non-minimum phase MA system with two zeros located at (0.8,1.25), (0.9,1.11), (0.94,1.063) and (0.98,1.0204).
- (3) snr - 3 levels: 20db, 5db and noiseless.
- (4) noise - 2 types: white and colored Gaussian distributed.

Total number of cases is 48. That means that each method has been tested by 48 different conditions. Each case has 30 times Monte Carlo simulations. So, total number of simulations for each method is 1440.

B. Parameter setting table

case no.	data length		signal AR coeff.			signal MA coeff.			pdf	SNR	Noise AR coeff.			Noise MA coeff.			pdf
	1	2	3	4	5	6	7	8			11	12	13	14	15	16	
1						zeros	0.8	1.25			20						
2						zeros	0.9	1.11									
3						zeros	0.94	1.063									
4						zeros	0.98	1.0204									
5						zeros	0.8	1.25			5						
6						zeros	0.9	1.11									
7						zeros	0.94	1.063									
8						zeros	0.98	1.0204									
9						zeros	0.8	1.25			0						
10						zeros	0.9	1.11									
11						zeros	0.94	1.063									
12						zeros	0.98	1.0204									
13						zeros	0.8	1.25			20						
14						zeros	0.9	1.11									
15						zeros	0.94	1.063									
16						zeros	0.98	1.0204									
17						zeros	0.8	1.25			5						
18						zeros	0.9	1.11									
19						zeros	0.94	1.063									
20						zeros	0.98	1.0204									
21						zeros	0.8	1.25			0						
22						zeros	0.9	1.11									
23						zeros	0.94	1.063									
24						zeros	0.98	1.0204									
25						zeros	0.8	1.25			20						
26						zeros	0.9	1.11									
27						zeros	0.94	1.063									
28						zeros	0.98	1.0204									
29						zeros	0.8	1.25			5						
30						zeros	0.9	1.11									
31						zeros	0.94	1.063									
32						zeros	0.98	1.0204									
33						zeros	0.8	1.25			0						
34						zeros	0.9	1.11									
35						zeros	0.94	1.063									
36						zeros	0.98	1.0204									
37						zeros	0.8	1.25			20						
38						zeros	0.9	1.11									
39						zeros	0.94	1.063									
40						zeros	0.98	1.0204									
41						zeros	0.8	1.25			5						
42						zeros	0.9	1.11									
43						zeros	0.94	1.063									
44						zeros	0.98	1.0204									
45						zeros	0.8	1.25			0						
46						zeros	0.9	1.11									
47						zeros	0.94	1.063									
48						zeros	0.98	1.0204									

1,0,0,1,0,0
(White)

1,4563,0,81,1,2,1
(Colored)

C. Output figures and data

For figures, see Appendix, pages 14-61. MSE's of impulse response for each method and each case are listed below.

Table 1. Mean and std. of MSE's of IR for GM+T method

1	0.1012 0.0007	5	0.0754 0.0006	9	0.0647 0.0003		13	0.0705 0.0002	17	0.0508 0.0003	21	0.0408 0.0004
2	0.0612 0.0002	6	0.0690 0.0004	10	0.0606 0.0003		14	0.0662 0.0003	18	0.0510 0.0004	22	0.0381 0.0003
3	0.0784 0.0004	7	0.0571 0.0004	11	0.0671 0.0004		15	0.0612 0.0002	19	0.0647 0.0004	23	0.0416 0.0003
4	0.0804 0.0004	8	0.0512 0.0004	12	0.0642 0.0003		16	0.0412 0.0003	20	0.0547 0.0004	24	0.0395 0.0001
25	0.0419 0.0003	29	0.0311 0.0001	33	0.0508 0.0003		37	0.0279 0.0003	41	0.0410 0.0003	45	0.0271 0.0002
26	0.0507 0.0004	30	0.0328 0.0002	34	0.0443 0.0003		38	0.0413 0.0003	42	0.0388 0.0004	46	0.0272 0.0003
27	0.0489 0.0001	31	0.0390 0.0002	35	0.0478 0.0004		39	0.0514 0.0004	43	0.0392 0.0003	47	0.0283 0.0002
28	0.0531 0.0002	32	0.0320 0.0004	36	0.0508 0.0002		40	0.0435 0.0003	44	0.0256 0.0003	48	0.0341 0.0003

Table 2. Mean and std. of MSE's for bicepstrum method.

1	0.0812 0.0004	5	0.0751 0.0005	9	0.0582 0.0002	13	0.0602 0.0002	17	0.0615 0.0004	21	0.0483 0.0001
2	0.0863 0.0005	6	0.0792 0.0007	10	0.0736 0.0003	14	0.0789 0.0003	18	0.0803 0.0005	22	0.0504 0.0001
3	0.0907 0.0006	7	0.0926 0.0006	11	0.0801 0.0005	15	0.0825 0.0002	19	0.0950 0.0005	23	0.0700 0.0002
4	0.0983 0.0005	8	0.0990 0.0007	12	0.0827 0.0003	16	0.0804 0.0004	20	0.0983 0.0005	24	0.0779 0.0002
25	0.0836 0.0003	29	0.0801 0.0006	33	0.0501 0.0002	37	0.0838 0.0002	41	0.0750 0.0004	45	0.0422 0.0001
26	0.0899 0.0007	30	0.0887 0.0006	34	0.0699 0.0003	38	0.0905 0.0004	42	0.0806 0.0006	46	0.0580 0.0002
27	0.0902 0.0005	31	0.0913 0.0005	35	0.0737 0.0004	39	0.0882 0.0004	43	0.0899 0.0004	47	0.0627 0.0002
28	0.0921 0.0004	32	0.0790 0.0004	36	0.0835 0.0004	40	0.0904 0.0004	44	0.0786 0.0004	48	0.0794 0.0002

Table 3. Mean and std. of MSE's for MU method.

1	0.4125	5	0.8521	9	1.0231	13	0.7612	17	0.7620	21	1.0110
	0.0491		0.0101		0.1124		0.0011		0.0010		0.0841
2	0.5271	6	0.8492	10	1.0601	14	0.8357	18	0.8510	22	1.0400
	0.0733		0.0892		0.1570		0.0517		0.0463		0.0720
3	0.6289	7	0.4665	11	1.0889	15	0.6006	19	0.5997	23	1.0895
	0.0925		0.0502		0.1749		0.0411		0.0408		0.0858
4	0.6280	8	0.3823	12	1.1211	16	0.3981	20	0.4201	24	1.1236
	0.0918		0.0493		0.1695		0.0457		0.0425		0.0607
25	0.4123	29	0.5029	33	0.4099	37	0.4127	41	0.5001	45	0.8071
	0.0442		0.0531		0.0400		0.0487		0.0470		0.0400
26	0.8372	30	0.5317	34	0.5126	38	0.4130	42	0.5038	46	0.7089
	0.0608		0.0399		0.0479		0.0486		0.0301		0.0561
27	0.7321	31	0.6318	35	0.6347	39	0.5321	43	0.5470	47	0.8033
	0.0819		0.0415		0.0825		0.0360		0.0298		0.0390
28	0.6394	32	0.6537	36	0.0499	40	0.5281	44	0.5366	48	0.8411
	0.0502		0.0416		0.0590		0.0302		0.0383		0.0301

Table 4. Mean ans std. of MSE's for RG method.

1	0.1002	5	0.1320	9	0.1011	13	0.1330	17	0.2086	21	0.1281
	0.0150		0.0498		0.0158		0.0510		0.0193		0.0382
2	0.1250	6	0.0138	10	0.1107	14	0.1335	18	0.1138	22	0.1107
	0.0188		0.0489		0.0092		0.0176		0.0322		0.0099
3	0.1376	7	0.1561	11	0.1298	15	0.1389	19	0.1266	23	0.1425
	0.0587		0.0590		0.0257		0.0603		0.0501		0.0633
4	0.1609	8	0.1788	12	0.1280	16	0.1463	20	0.1501	24	0.1832
	0.0803		0.0884		0.0050		0.0800		0.0745		0.0825
25	0.1008	29	0.1325	33	0.1106	37	0.1057	41	0.1006	45	0.1116
	0.0149		0.0512		0.0207		0.0231		0.0305		0.0188
26	0.1149	30	0.1388	34	0.1086	38	0.1600	42	0.1620	46	0.1125
	0.0143		0.0520		0.0085		0.0139		0.0599		0.0270
27	0.1367	31	0.1721	35	0.1405	39	0.1033	43	0.1837	47	0.1850
	0.0732		0.0726		0.0118		0.0182		0.0813		0.0753
28	0.1597	32	0.1811	36	0.1205	40	0.1010	44	0.1790	48	0.1831
	0.0865		0.0918		0.0039		0.0125		0.0806		0.0099

III. Discussion

If we say "good" or "better" that means the mean of MSE decreased and the standard deviation of MSE also decreases. If we just say "more stable" that only means the standard deviation decreases.

A. Compare output by data length

As data length increased from 128x4 to 128x8, some results get better at the cost of more computing time.

	<u>IR coef.</u>	<u>magnitude</u>	<u>phase</u>
GM+T	better	a few better	a few better
Biceps	better	better	better
MU	some better	better	better
RG	some better	some better	some better

B. Compare output by zero's location

When zeros are getting closer to the unit circle at locations (0.8, 1.25), (0.9, 1.11), (0.94, 1.063) and (0.98, 1.020), the results are confused. Part of the 48 cases get better; however, some of them get worse.

	<u>IR coef.</u>	<u>magnitude</u>	<u>phase</u>
GM+T	some better	some better	some better
Biceps	worse	some better	worse
MU	some better	some better	some better
RG	some better	some better	some better

C. Compare output by snr

As snr increases from 5db, then 20db to noiseless , almost all cases get better except for very few cases of MU and RG methods.

	<u>IR coef.</u>	<u>magnitude</u>	<u>phase</u>
GM+T	better	better	better
Biceps	better	better	better
MU	a few worse	a few worse	a few worse
RG	better	a few worse	a few worse

D. Compare output by noise type

When noise distribution changes from white to colored Gaussian, GM+T and MU keep getting better but biceps and RG do not improve significantly.

	<u>IR coef.</u>	<u>magnitude</u>	<u>phase</u>
GM+T	better	better	better
Biceps	some better	some better	better
MU	better	better	better
RG	some better	some better	some better

IV. Conclusions

(1) In general, bicepstrum method shows very good performance for all cases, i.e. the lowest MSE and the smallest std. of MSE. But its magnitude estimates are not so stable as GM+T's, and its phase estimates are not as stable as RG. Which method is more suitable for your problem seem to depend on which factor, IR stability, magnitude or phase, concerns you the most.

(2) From the previous section, we can have a simple conclusion about the influence of data length. Bicepstrum and MU methods are more sensitive than GM+T and RG. The longer the data length is, the better the estimates in bicepstrum and MU methods. If computing time is important , GM+T and RG provides quick solution .

(3) Zeros location is an interesting question. Once I guessed that the results will be getting worse as zeros move toward the unit circle. After all data have been simulated, the results are so confusing that we can not have any conclusion on this variable. Only bicepstrum shows slight trend of getting worse when zeros more towards the unit circle.

(4) When snr increases, results should be better, just GM+T and biceps improve for all cases. RG and MU have some exceptions.

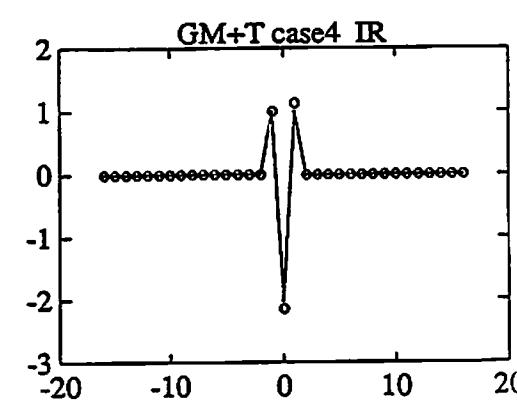
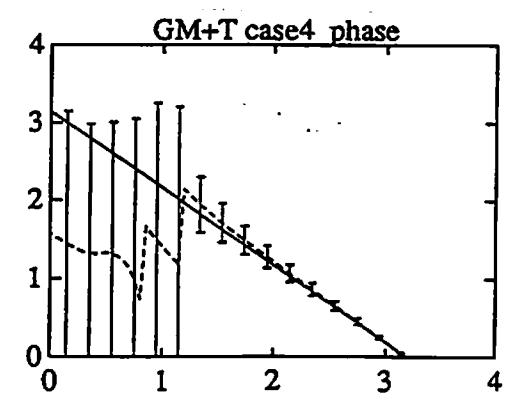
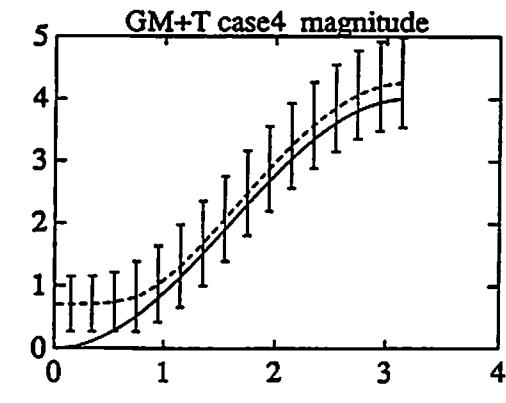
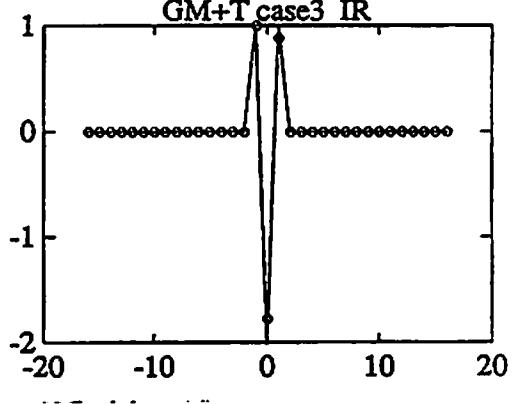
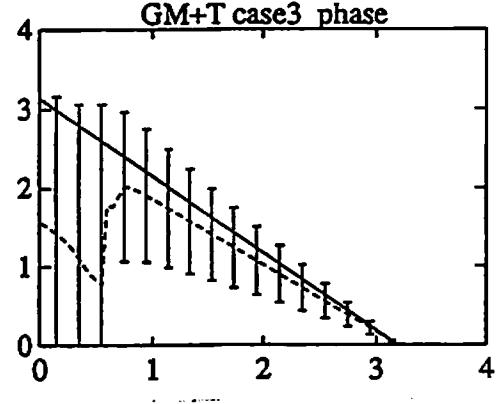
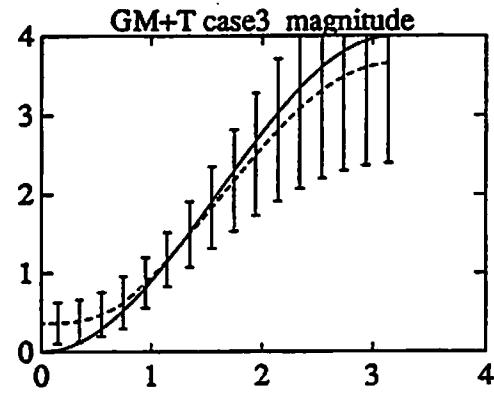
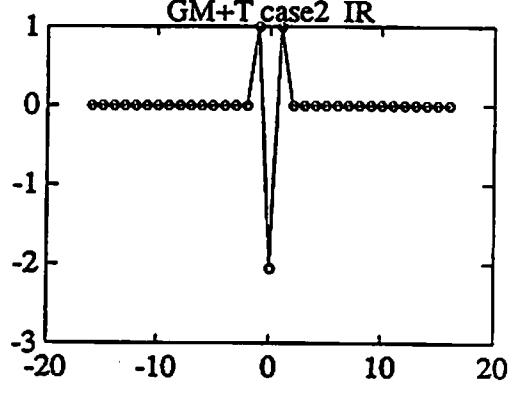
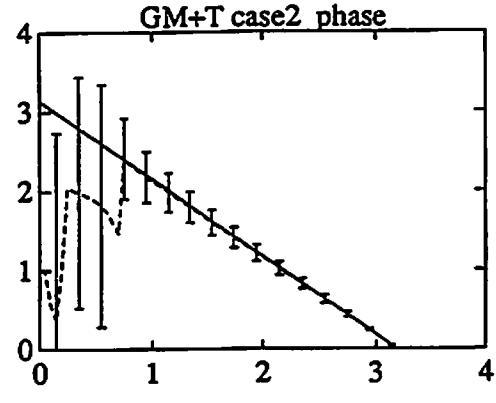
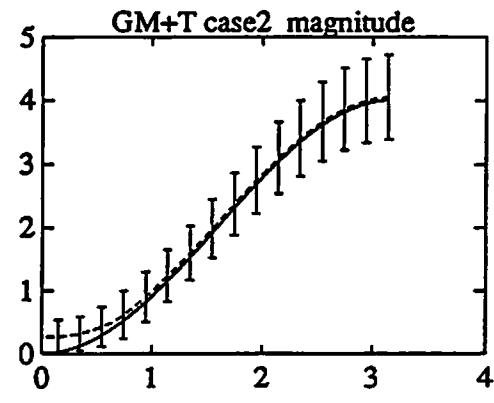
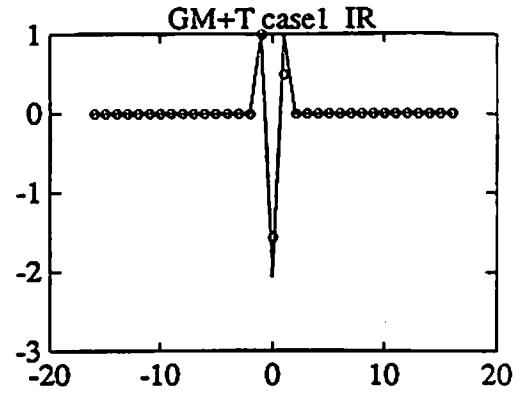
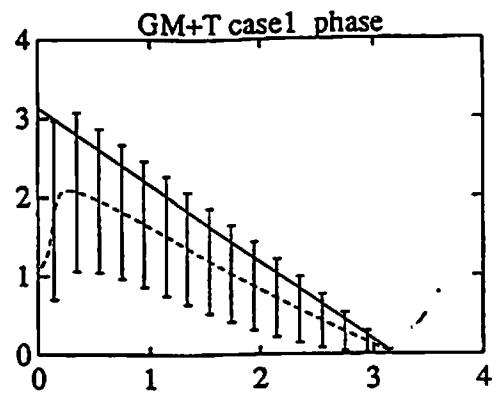
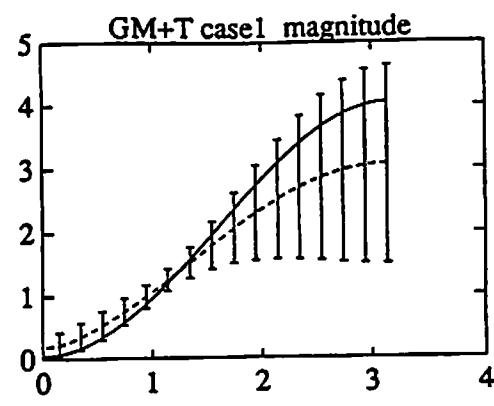
(5) As noise type changed from white to colored Gaussian, by our knowledge about the high-order spectrum, results will get better. GM+T, bicepstrum and MU have this property. RG's results has some exceptions about this.

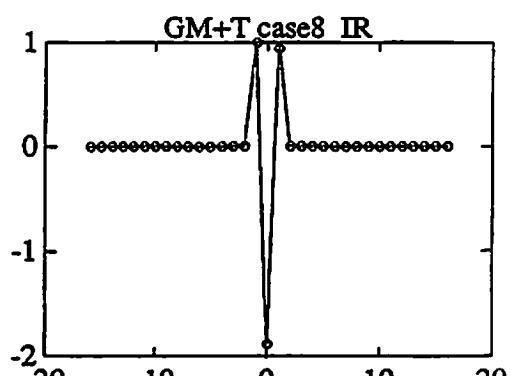
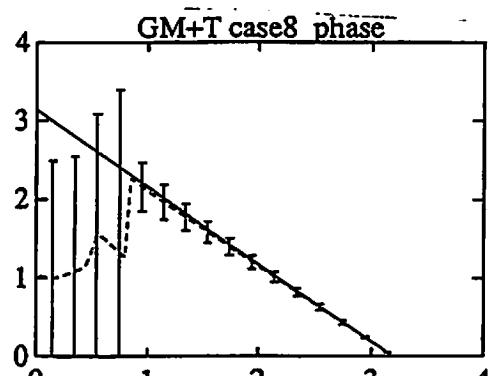
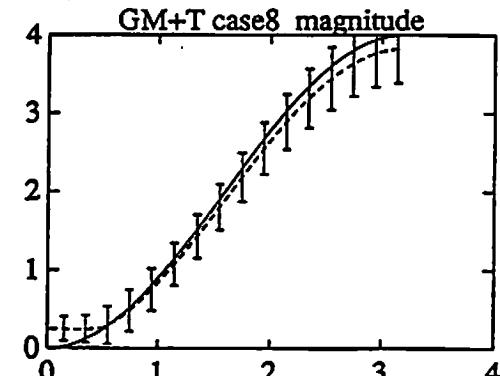
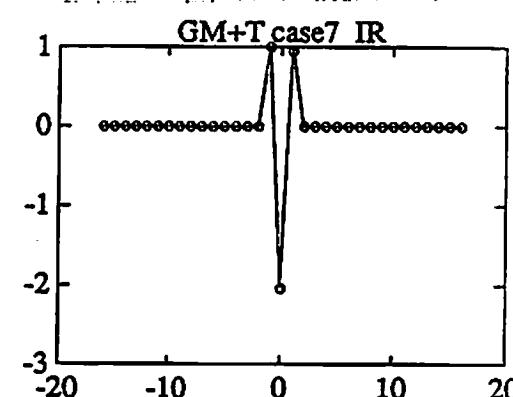
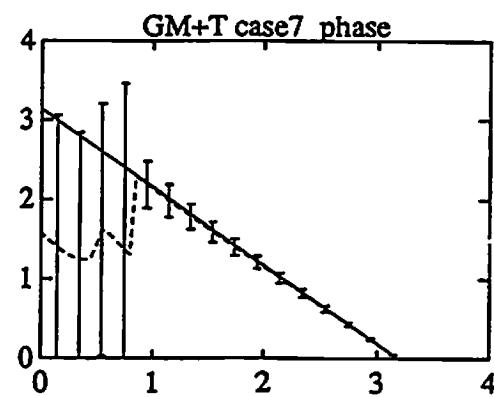
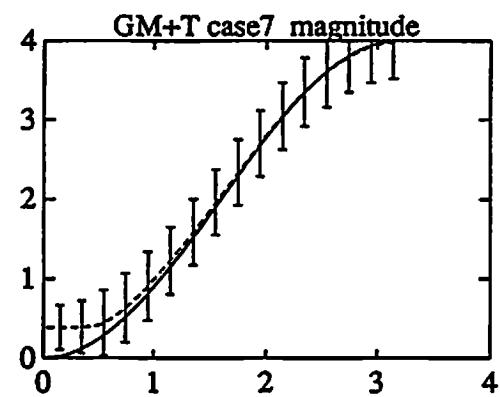
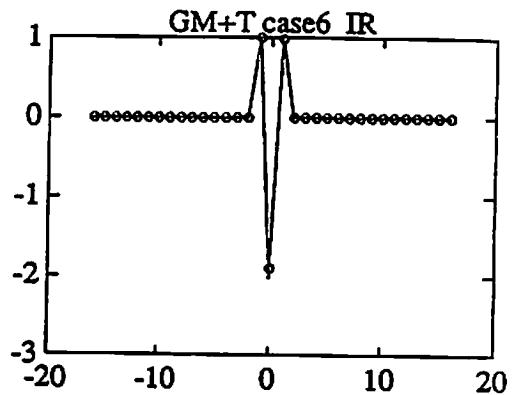
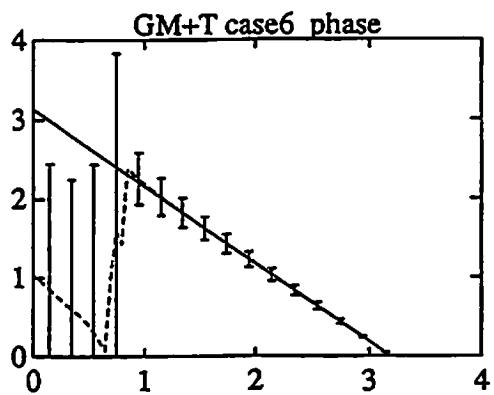
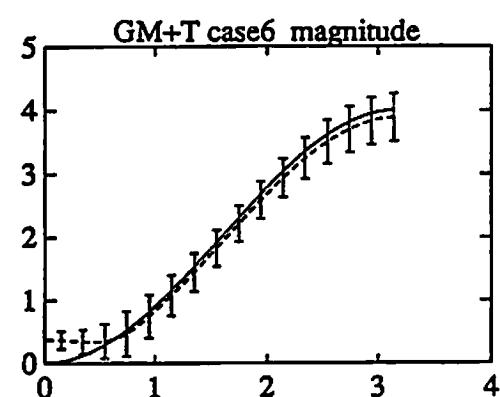
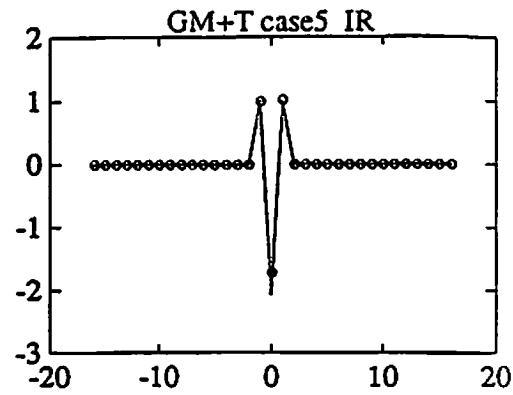
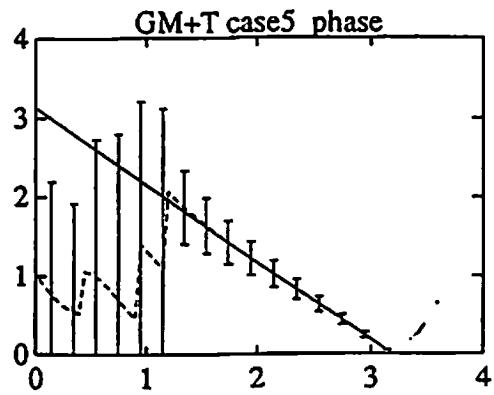
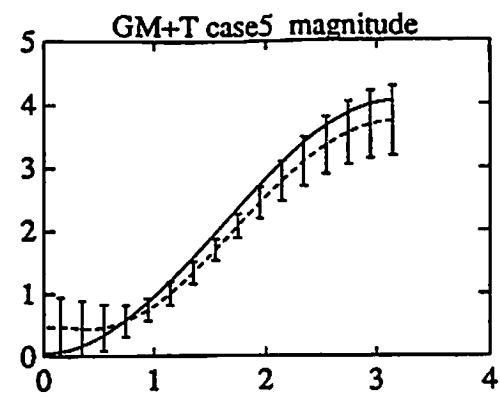
If one or more of these parameters, data length(or computing time), snr and noise type, are important, we suggest that you check the characteristics of each method before solving your problem.

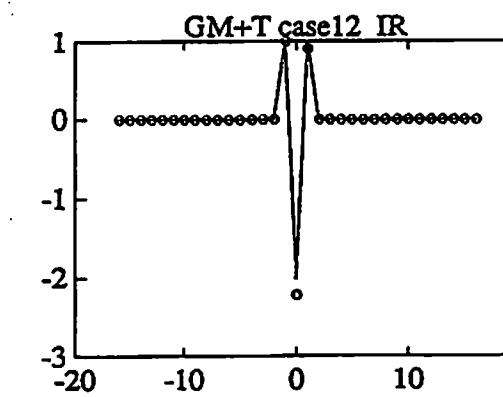
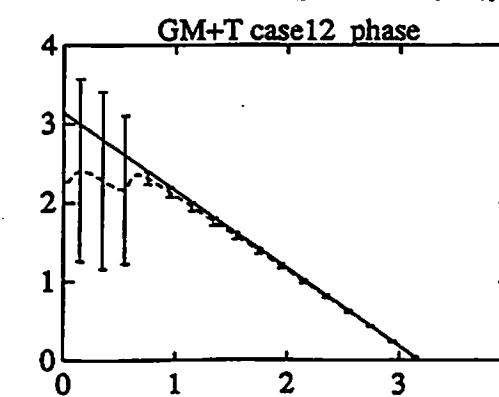
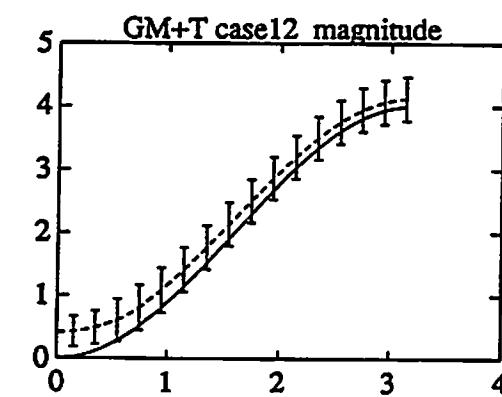
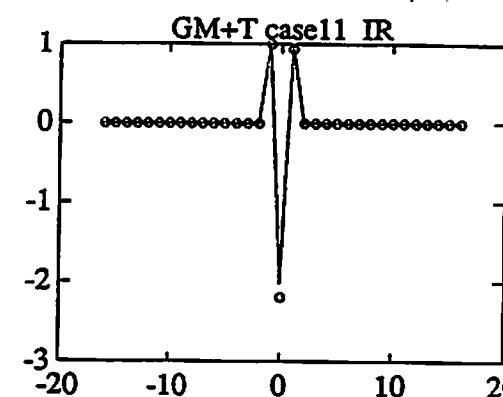
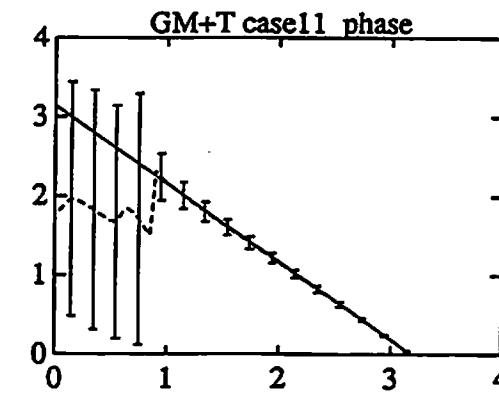
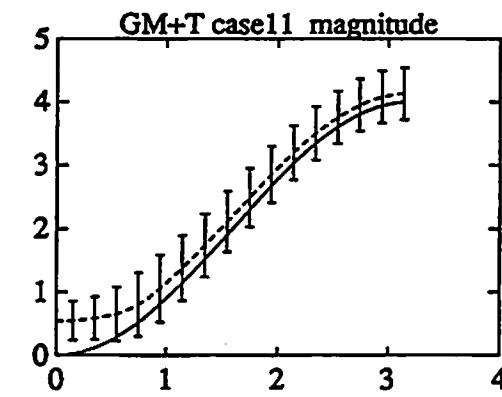
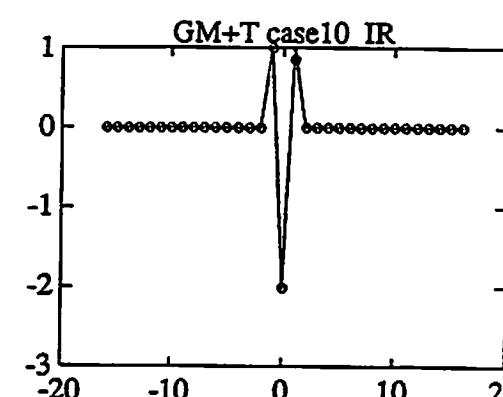
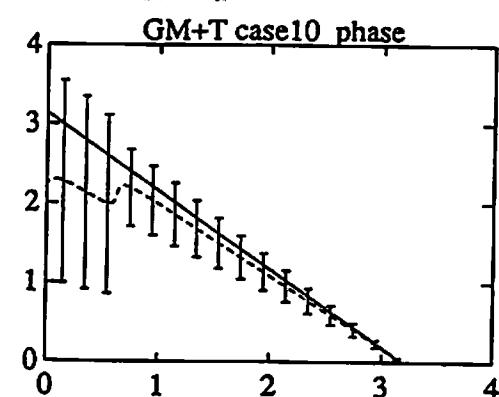
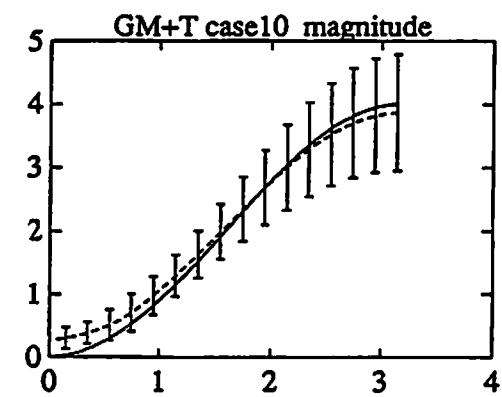
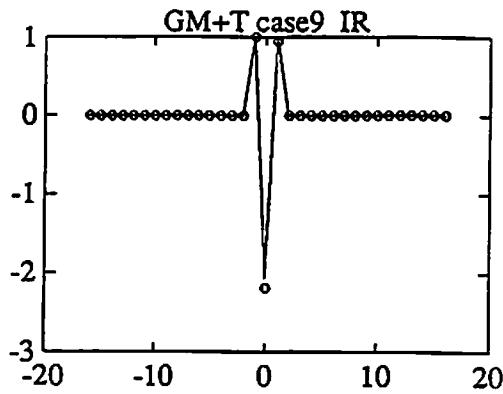
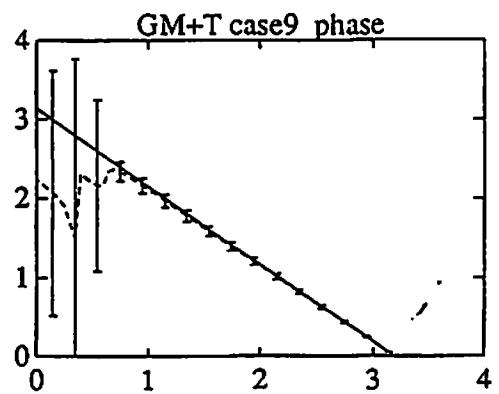
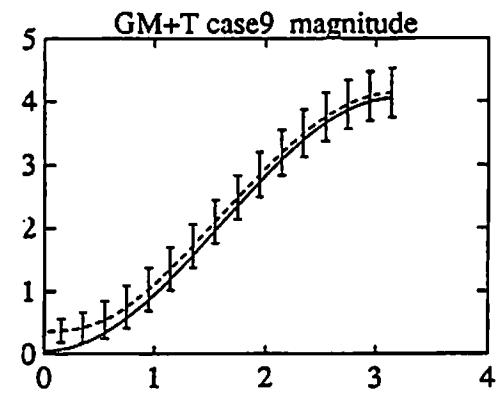
Reference

- (1) J. M. Mendel, "Tutorial on higher-order statistics (spectra) in signal processing and system theory: theoretical results and some applications," Proc. of IEEE, pp.278-305, 1991.
- (2) G. B. Giannakis and J. M. Mendel, "Identification of non-minimum phase systems using higher-order statistics," IEEE Trans. Acoustics, Speech, Signal Processing, vol.37, pp.360-377, Mar. 1989.
- (3) R. Pan and C. L. Nikias, "The complex cepstrum of higher-order cumulants and non-minimum phase system identification," IEEE trans. Acoustics, Speech, Signal Processing, vol.36, pp.186-205, 1988.
- (4) T. Matsuoka and T. J. Ulrych, "Phase estimation using the bispectrum," Proc. of IEEE, pp.1403-11, 1984.
- (5) M. Rangoussi and G. B. Giannakis, "FIR modeling using log-bispectra: weighted least-squares algorithms and performance analysis", IEEE Trans. Circuits and Systems, vol.38, pp.281-196, Mar. 1991.
- (6) Hi-Spec library, United Signal & Systems, Inc.
- (7) Dr. Swami, Ph.D. Thesis, "Simulations", pp.30-48.

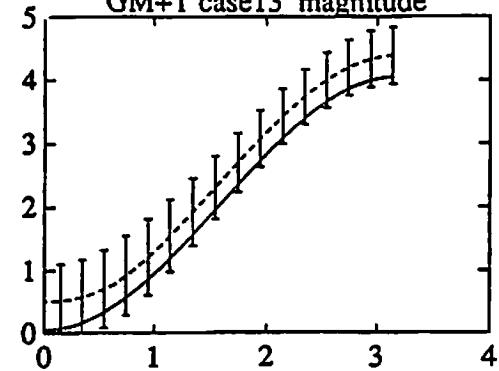
Appendix



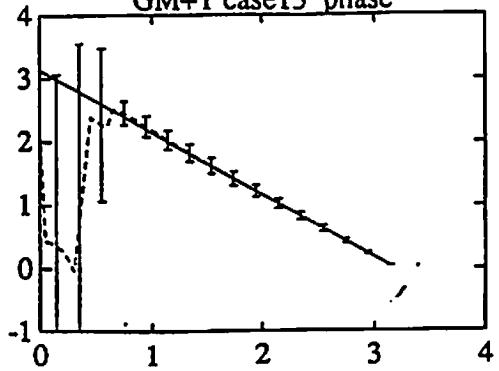




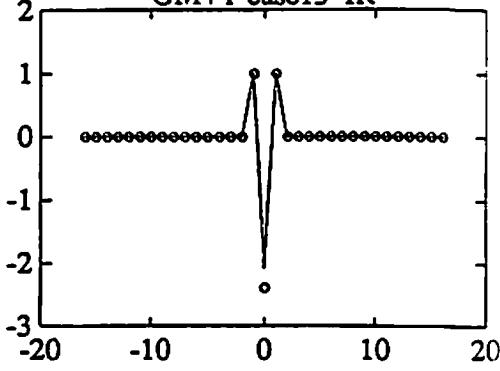
GM+T case13 magnitude



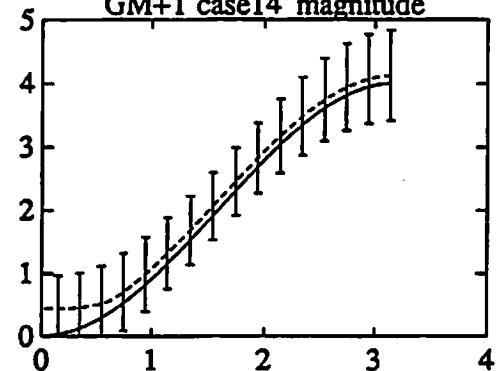
GM+T case13 phase



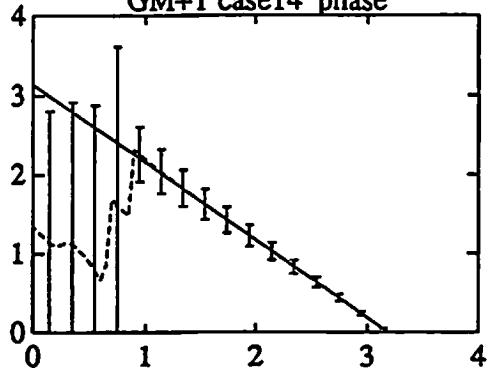
GM+T case13 IR



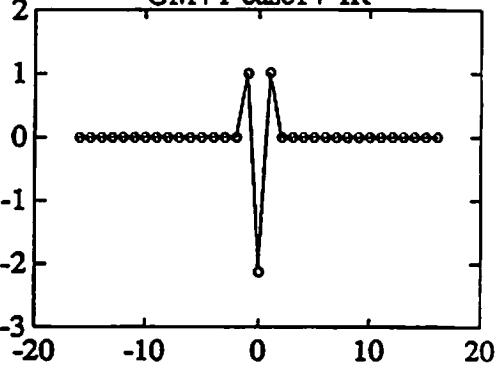
GM+T case14 magnitude



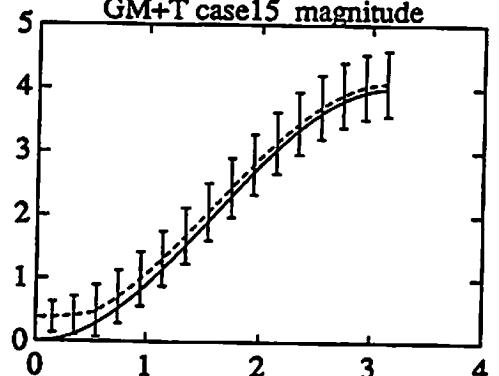
GM+T case14 phase



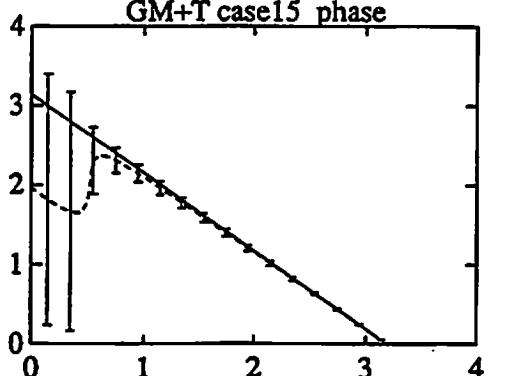
GM+T case14 IR



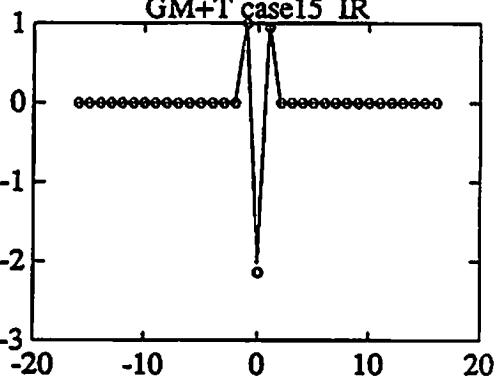
GM+T case15 magnitude



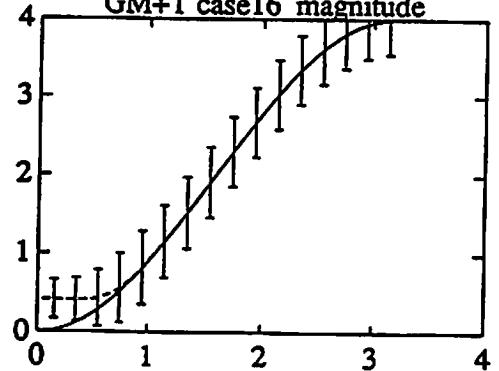
GM+T case15 phase



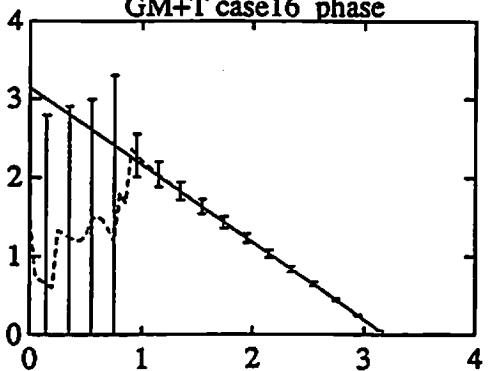
GM+T case15 IR



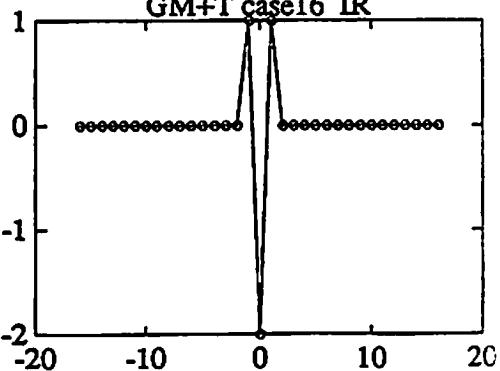
GM+T case16 magnitude



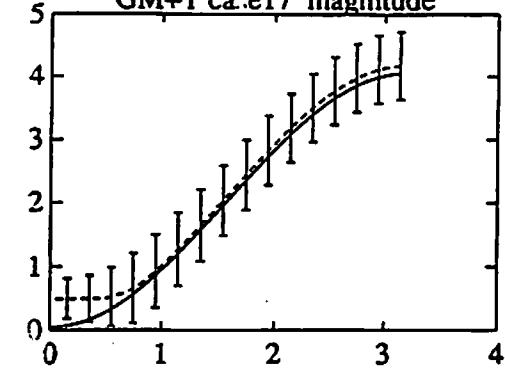
GM+T case16 phase



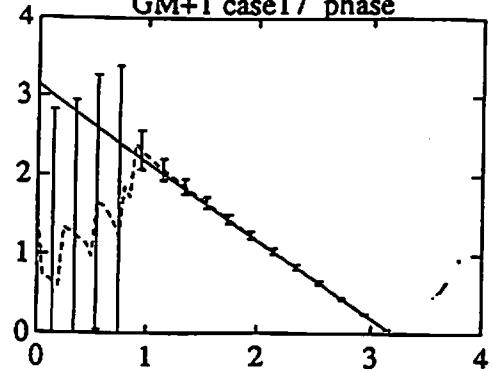
GM+T case16 IR



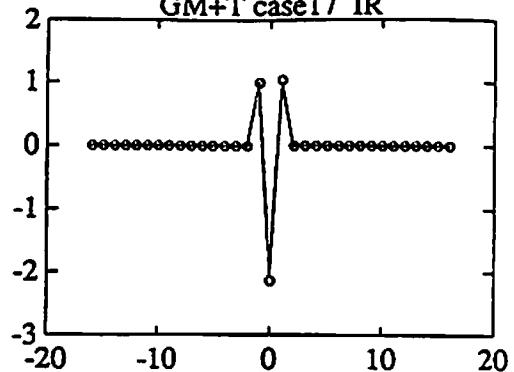
GM+T case17 magnitude



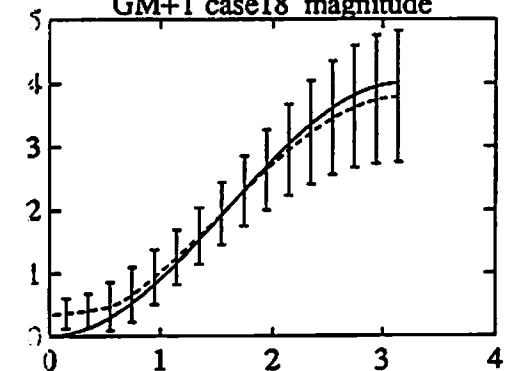
GM+T case17 phase



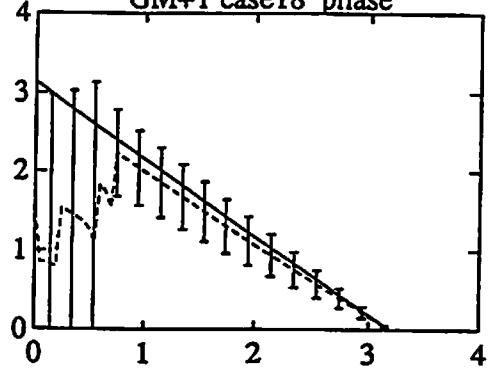
GM+T case17 IR



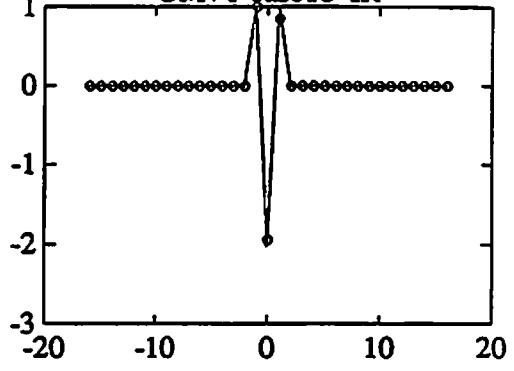
GM+T case18 magnitude



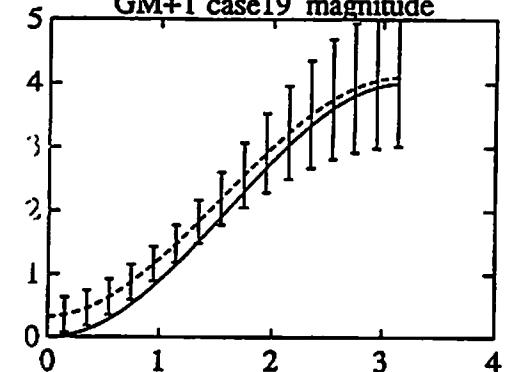
GM+T case18 phase



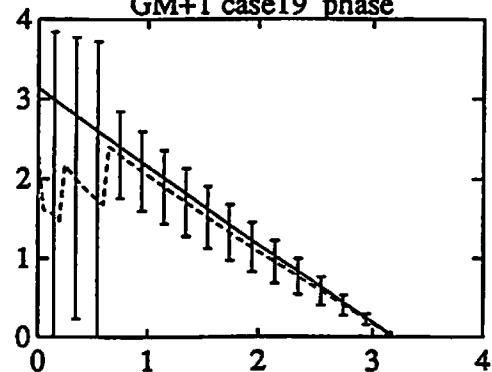
GM+T case18 IR



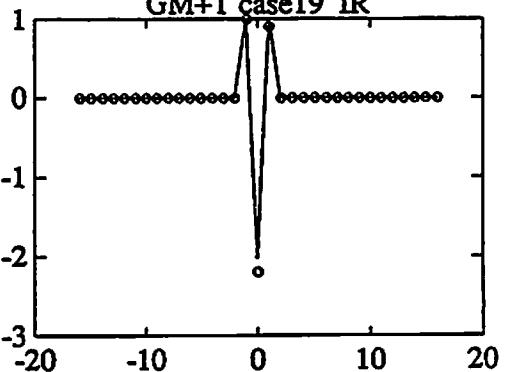
GM+T case19 magnitude



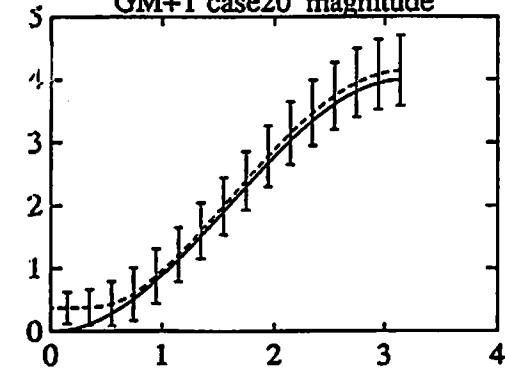
GM+T case19 phase



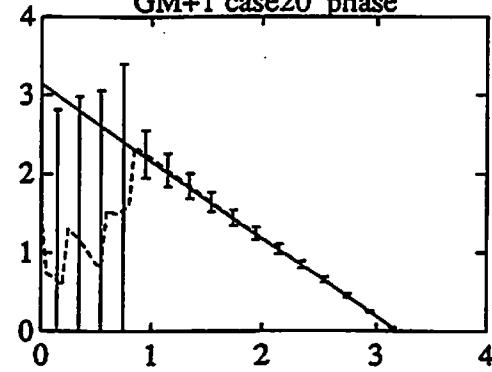
GM+T case19 IR



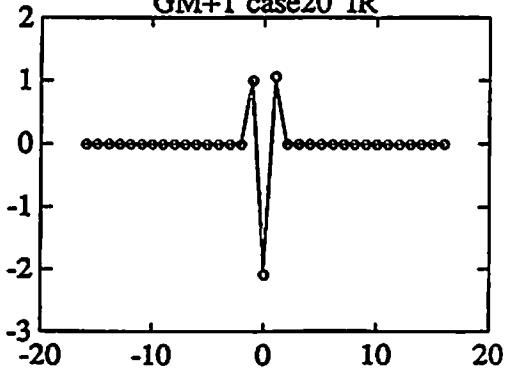
GM+T case20 magnitude



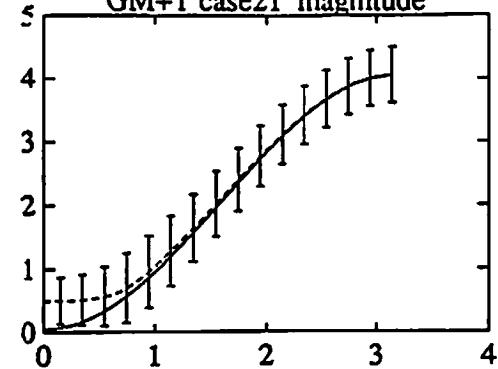
GM+T case20 phase



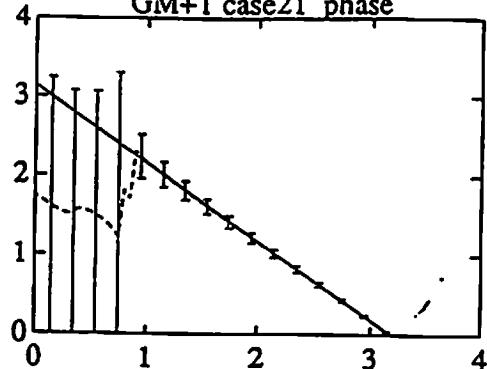
GM+T case20 IR



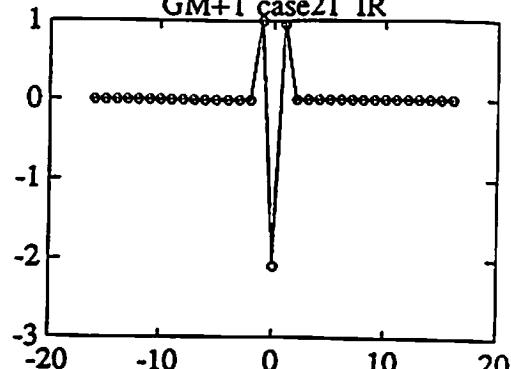
GM+T case21 magnitude



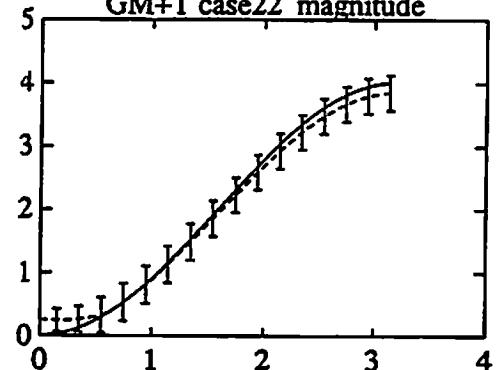
GM+T case21 phase



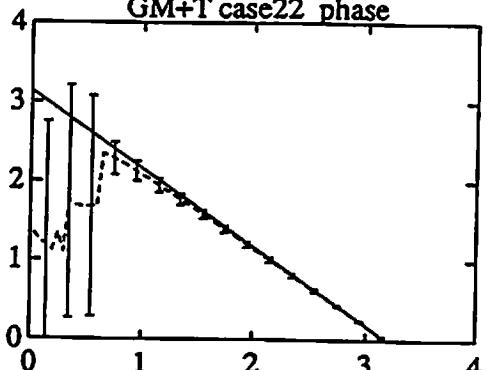
GM+T case21 IR



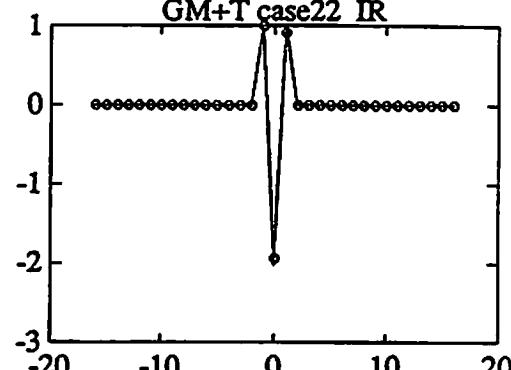
GM+T case22 magnitude



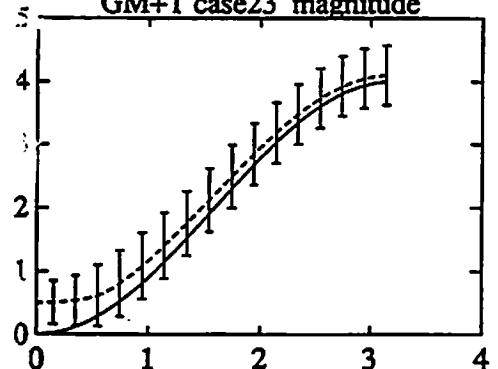
GM+T case22 phase



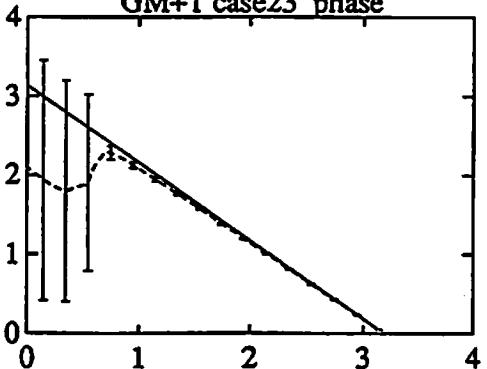
GM+T case22 IR



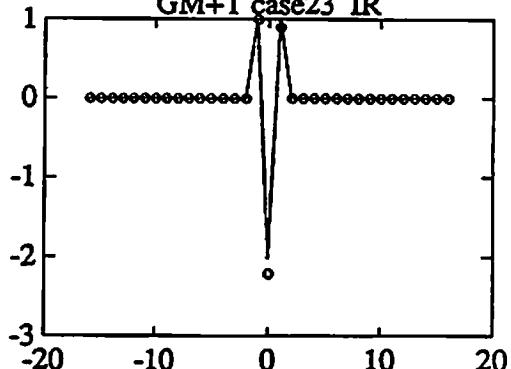
GM+T case23 magnitude



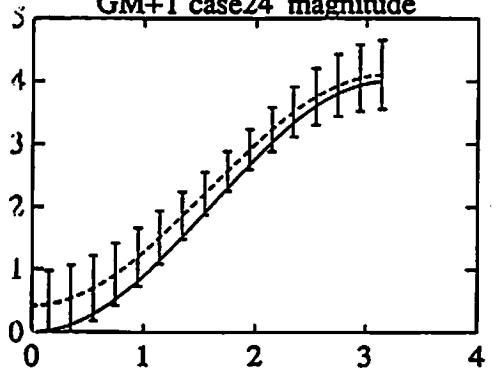
GM+T case23 phase



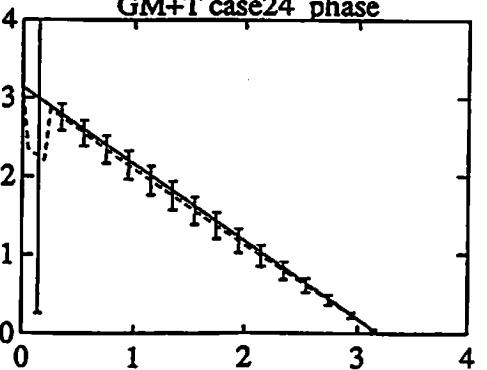
GM+T case23 IR



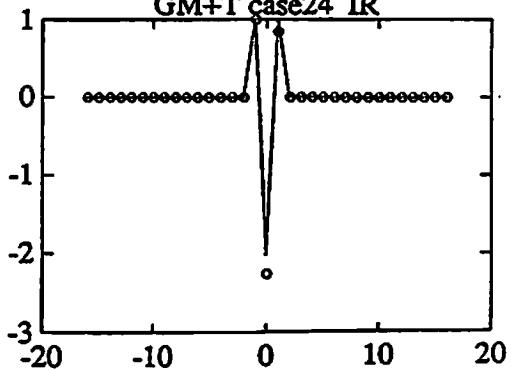
GM+T case24 magnitude

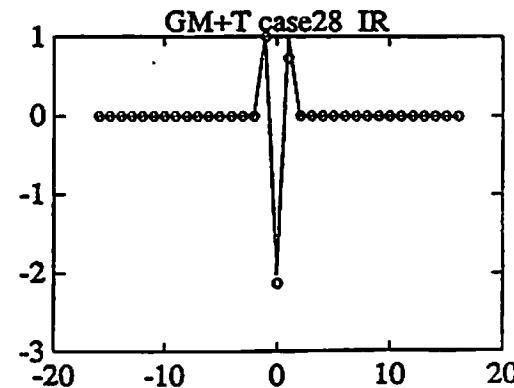
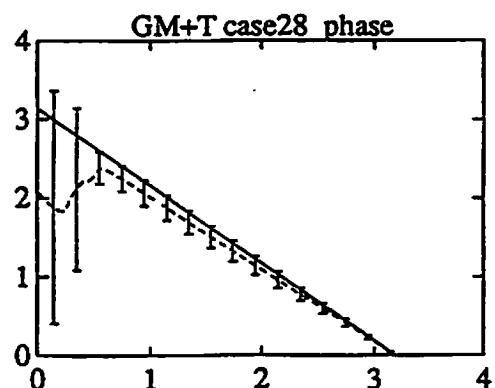
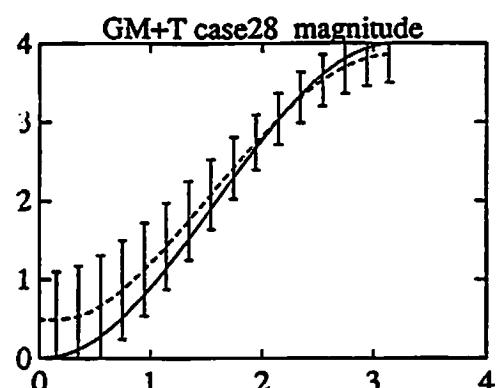
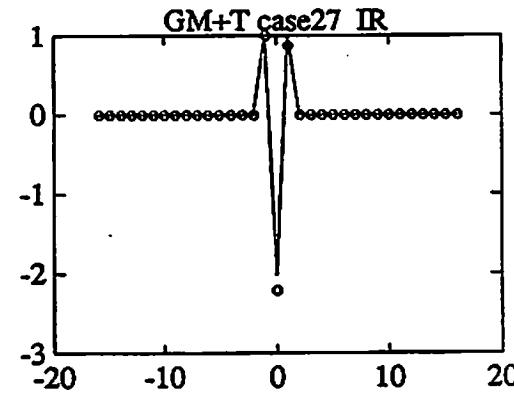
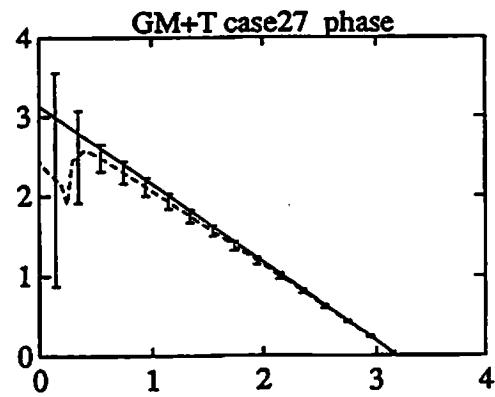
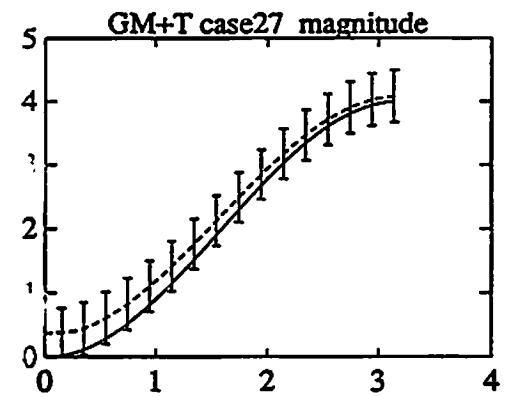
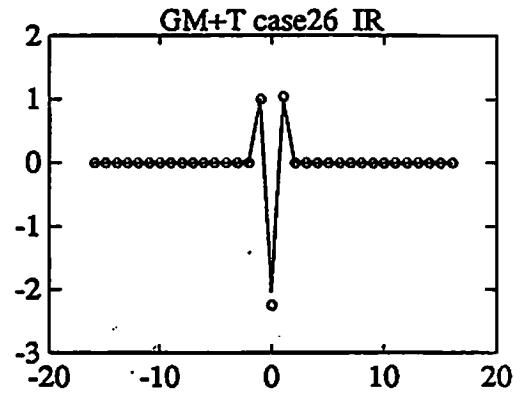
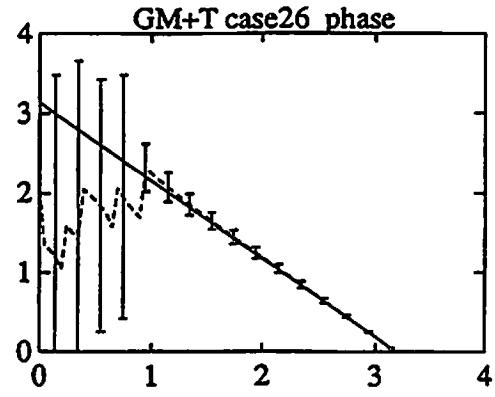
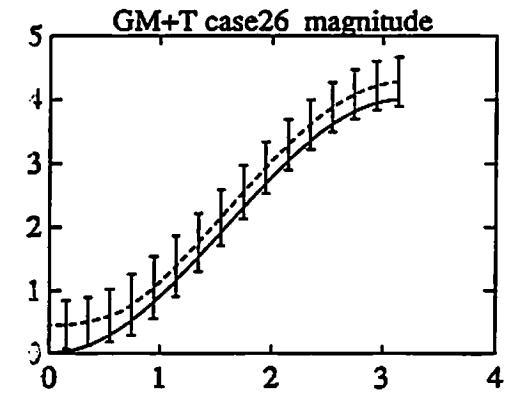
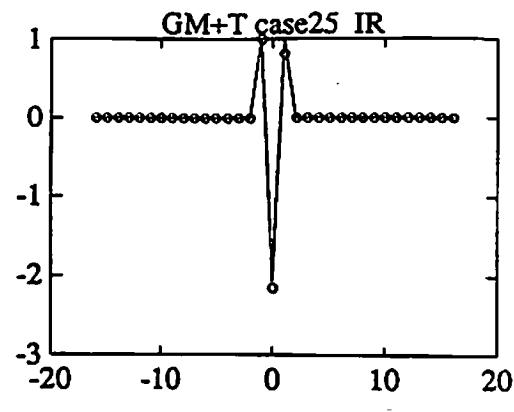
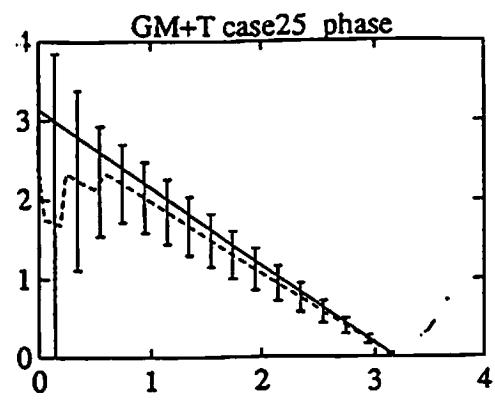
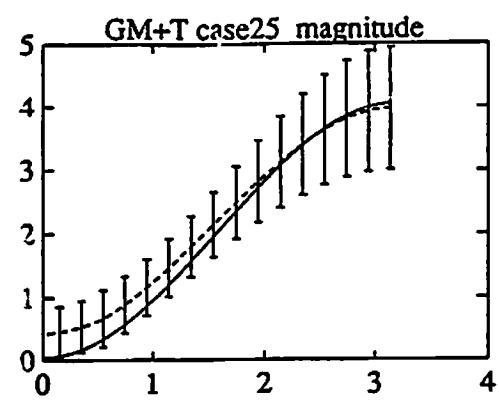


GM+T case24 phase

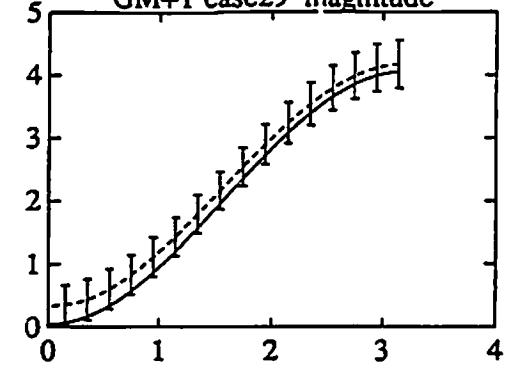


GM+T case24 IR

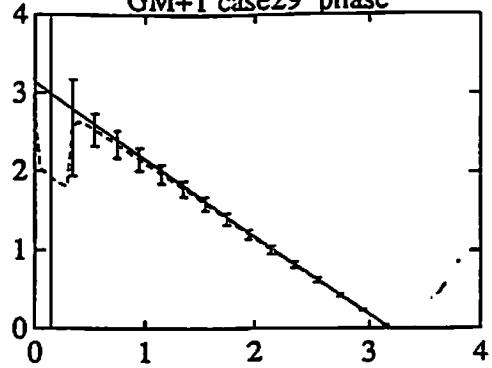




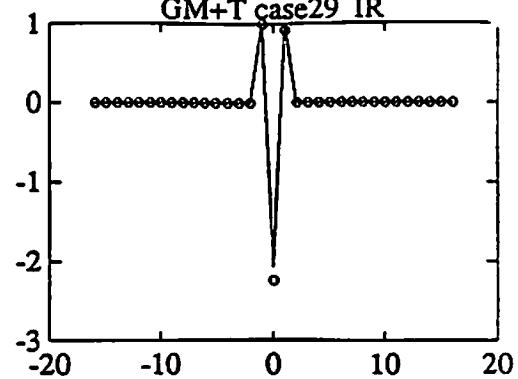
GM+T case29 magnitude



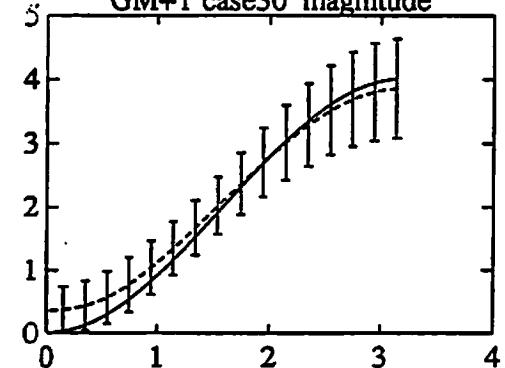
GM+T case29 phase



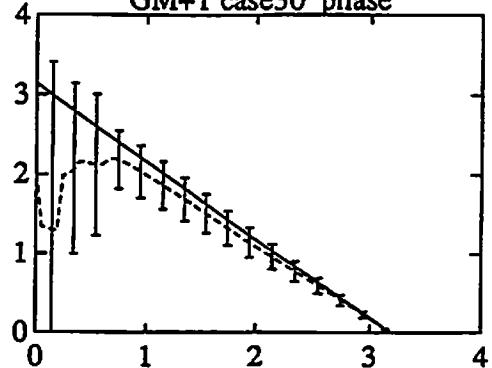
GM+T case29 IR



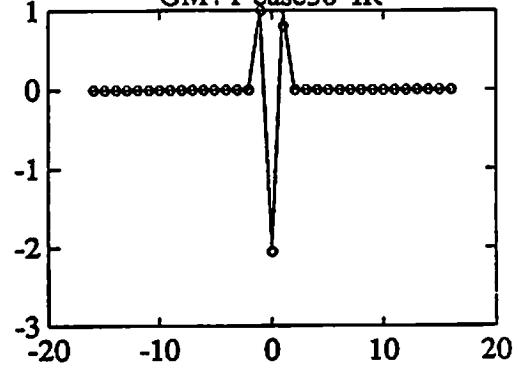
GM+T case30 magnitude



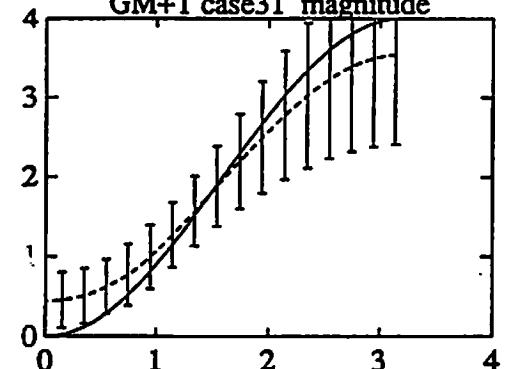
GM+T case30 phase



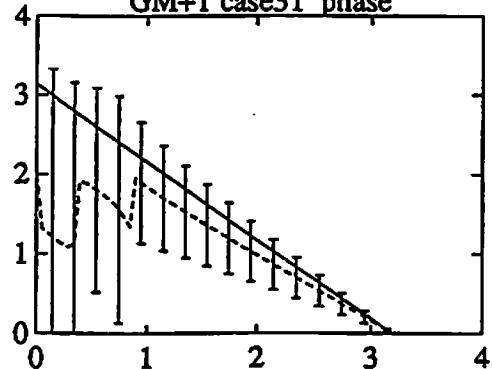
GM+T case30 IR



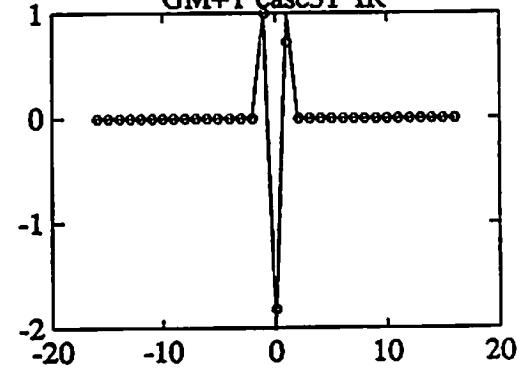
GM+T case31 magnitude



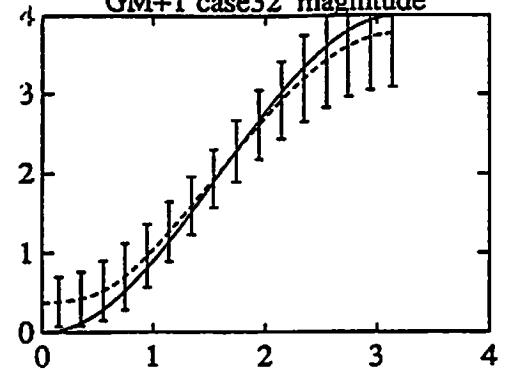
GM+T case31 phase



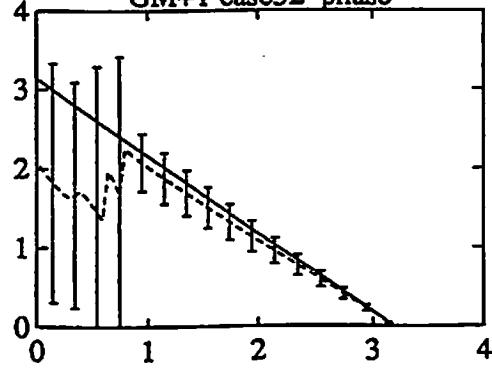
GM+T case31 IR



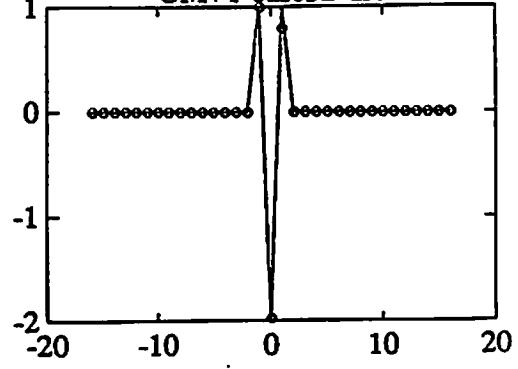
GM+T case32 magnitude



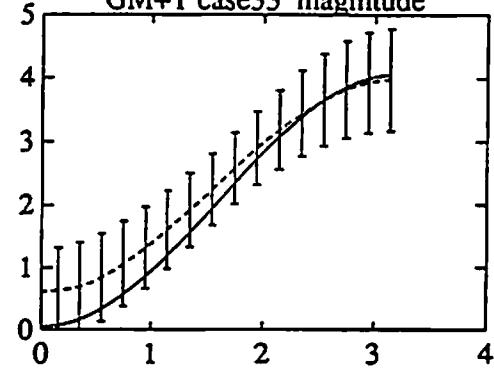
GM+T case32 phase



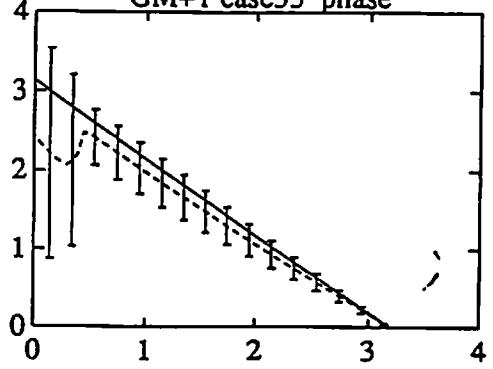
GM+T case32 IR



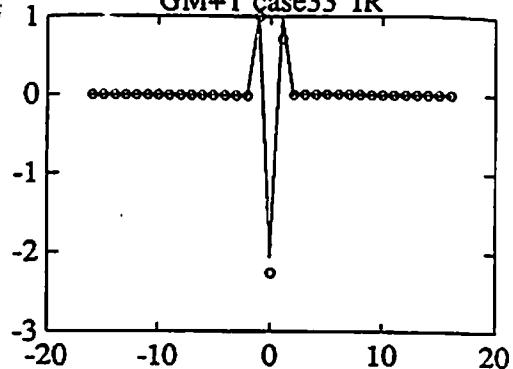
GM+T case33 magnitude



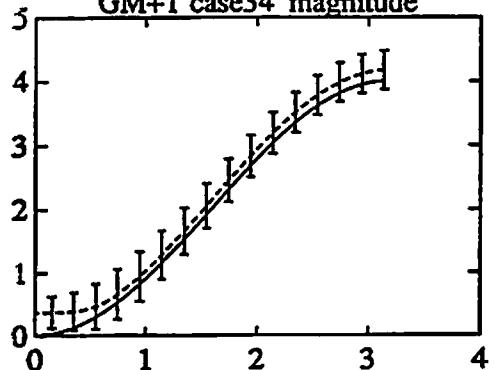
GM+T case33 phase



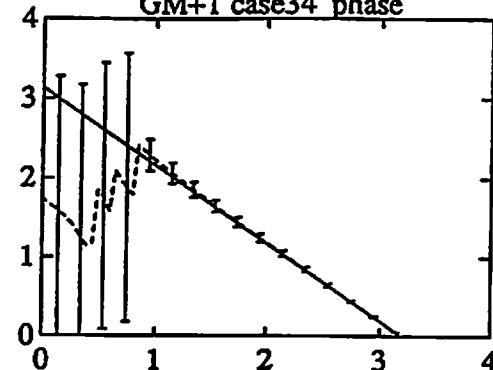
GM+T case33 IR



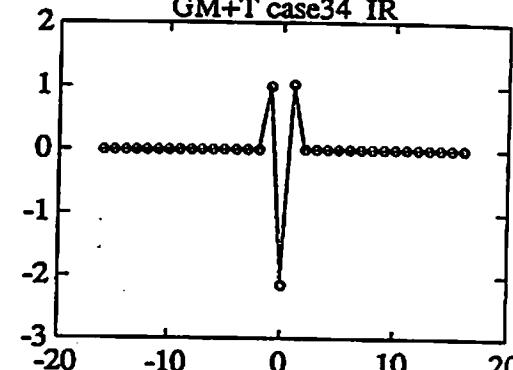
GM+T case34 magnitude



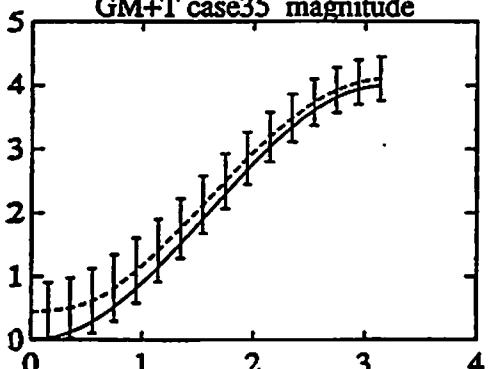
GM+T case34 phase



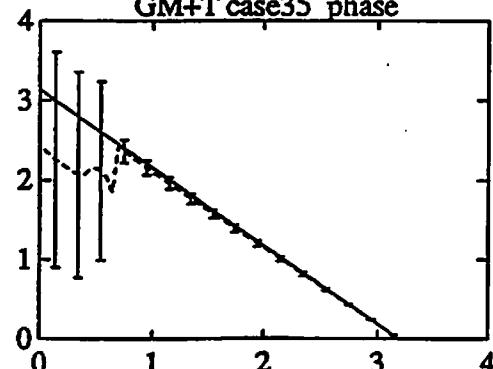
GM+T case34 IR



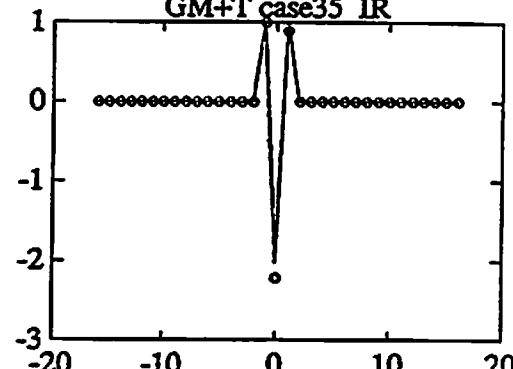
GM+T case35 magnitude



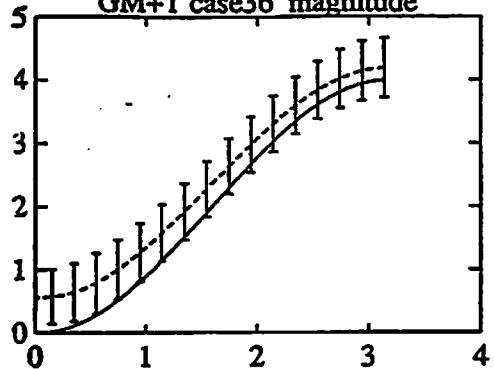
GM+T case35 phase



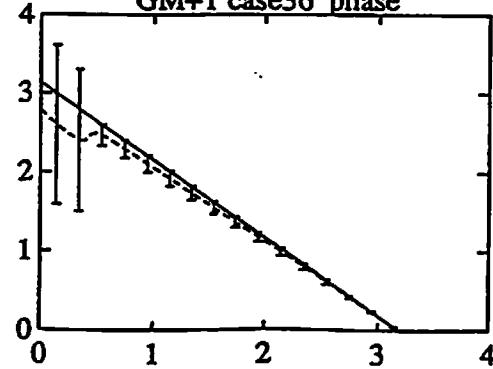
GM+T case35 IR



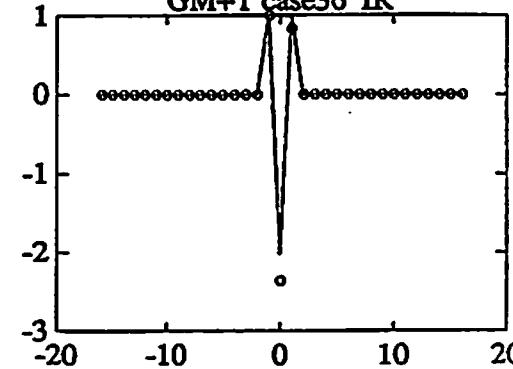
GM+T case36 magnitude

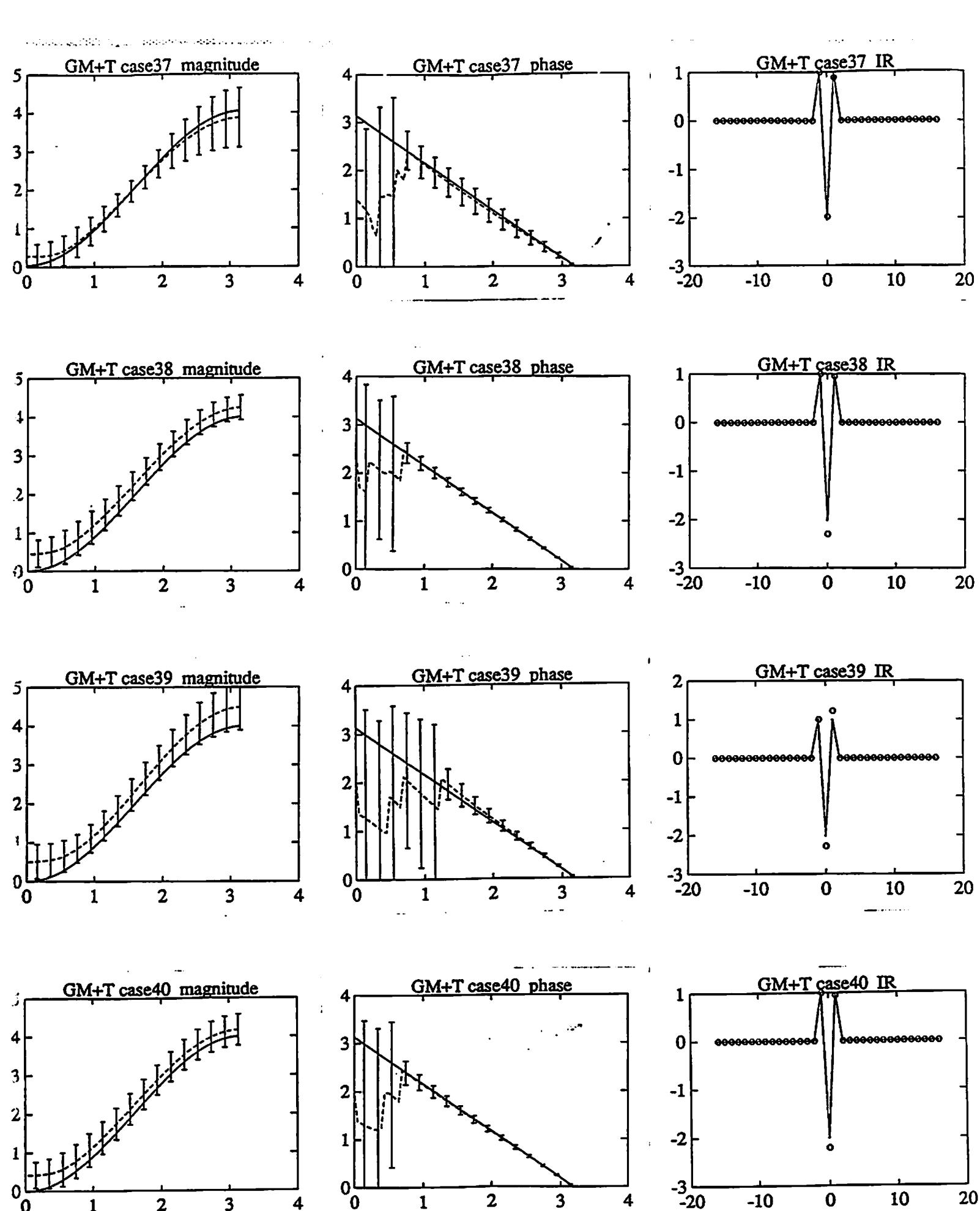


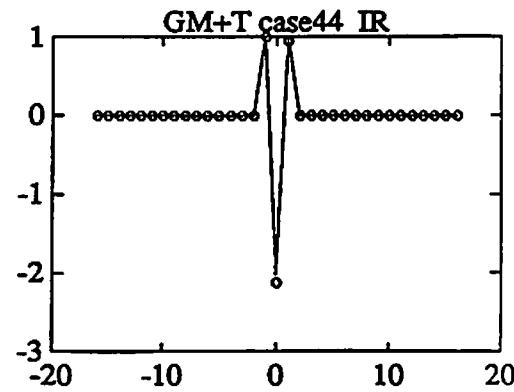
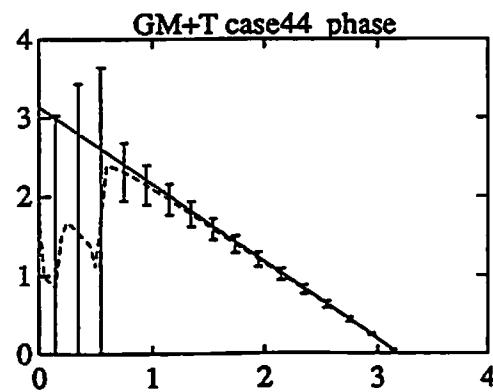
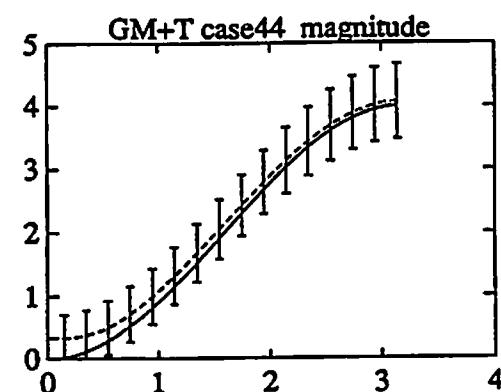
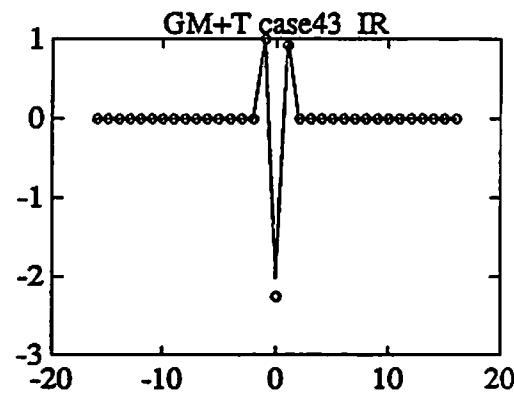
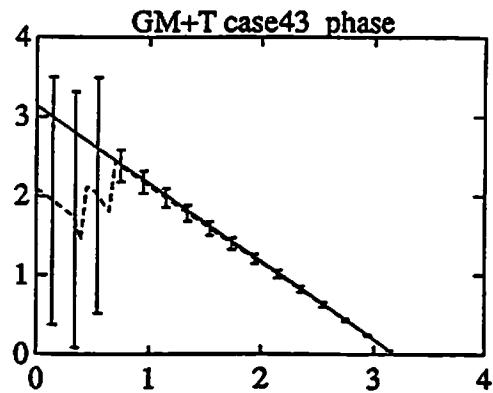
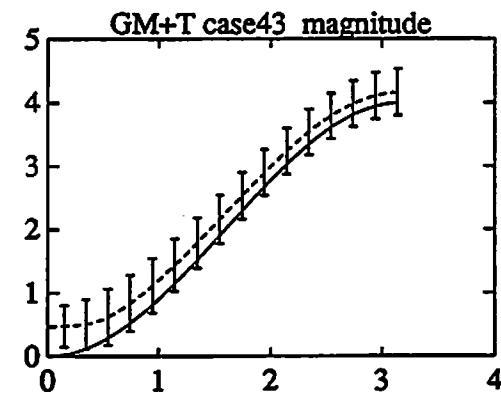
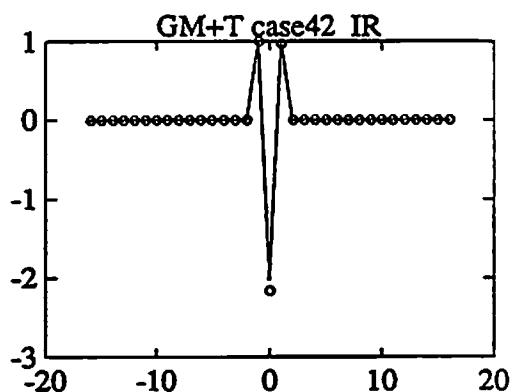
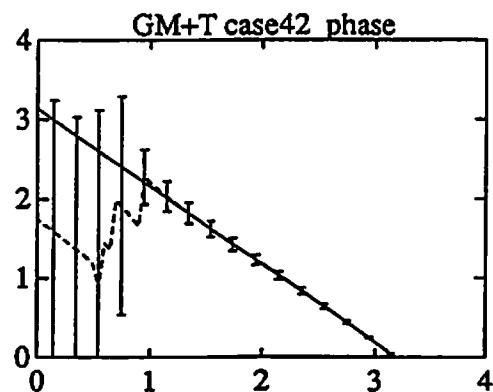
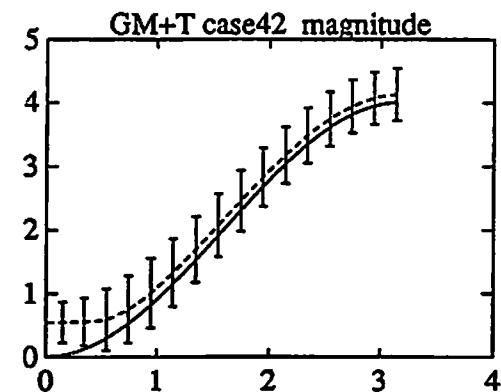
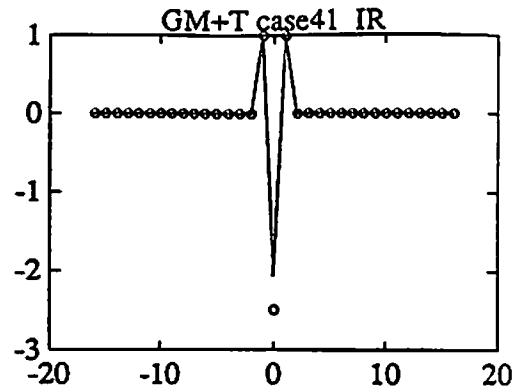
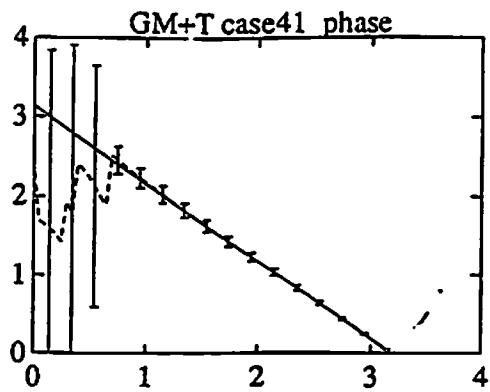
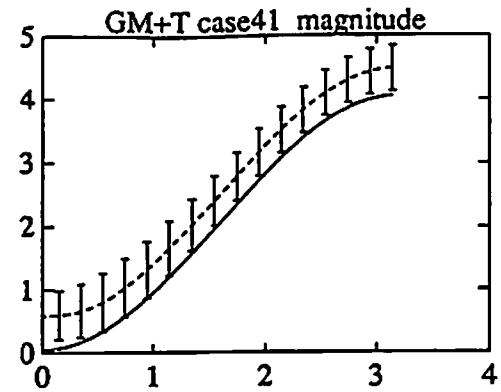
GM+T case36 phase

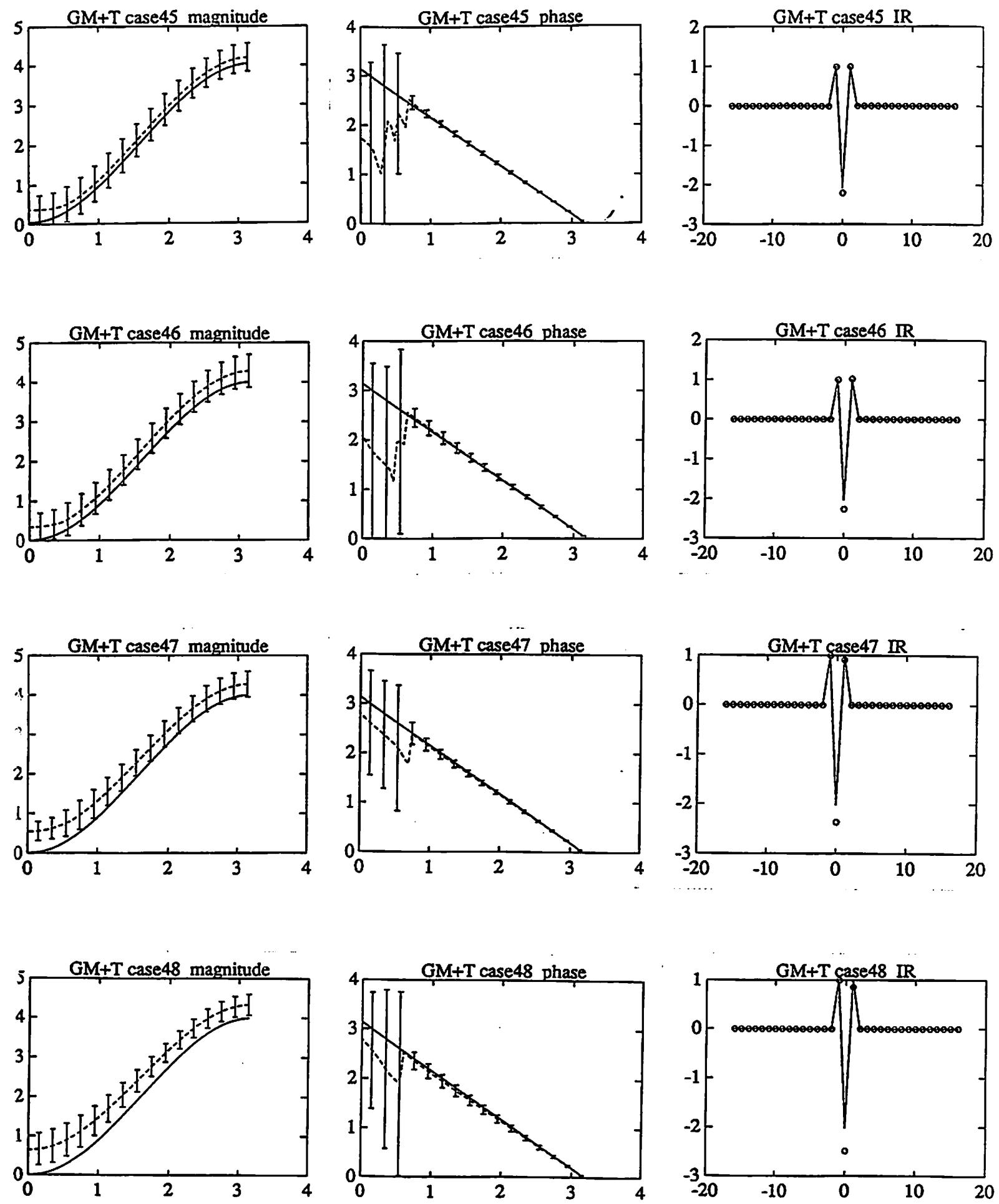


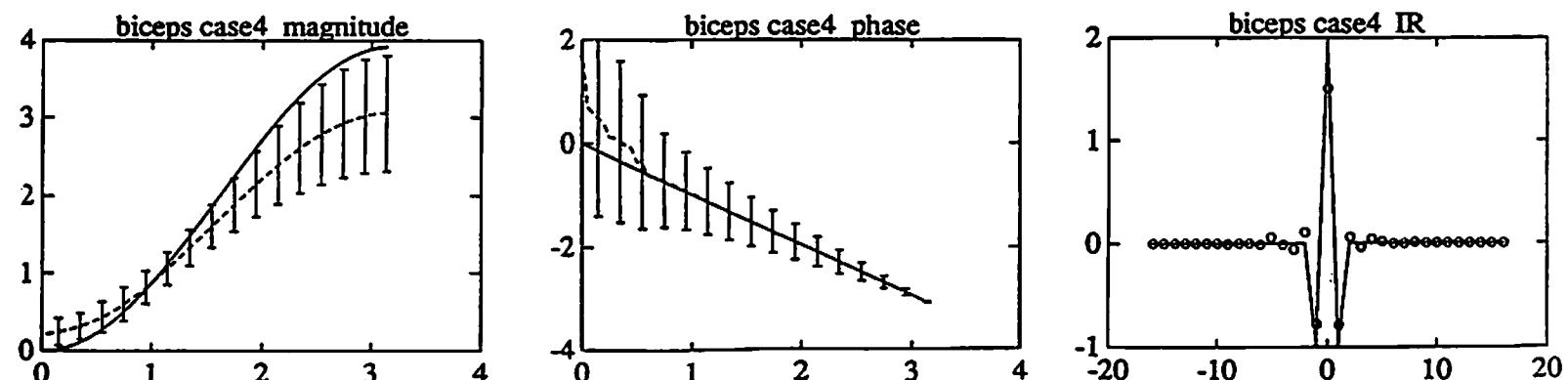
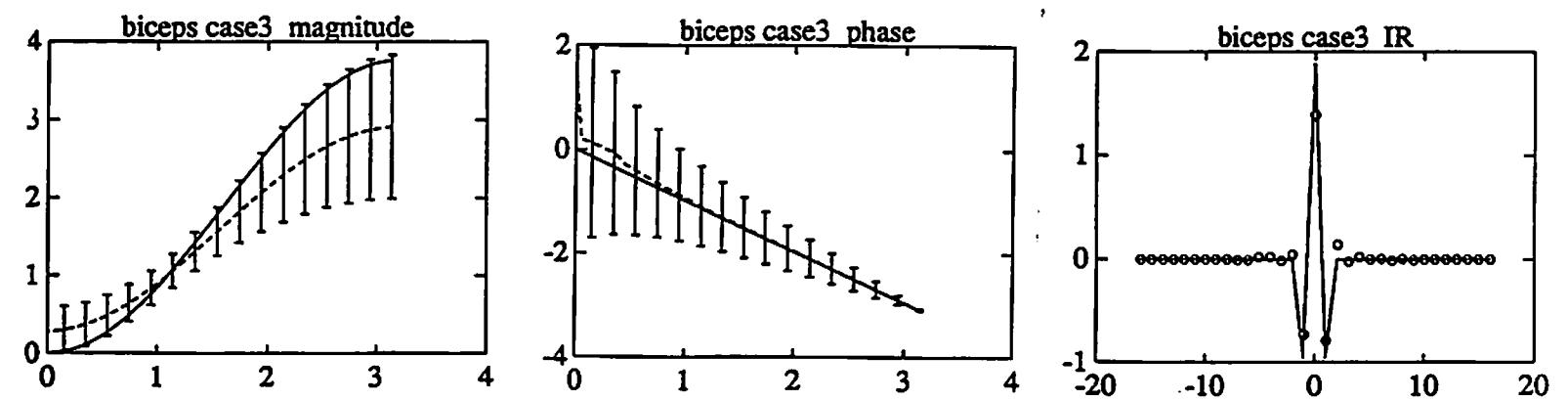
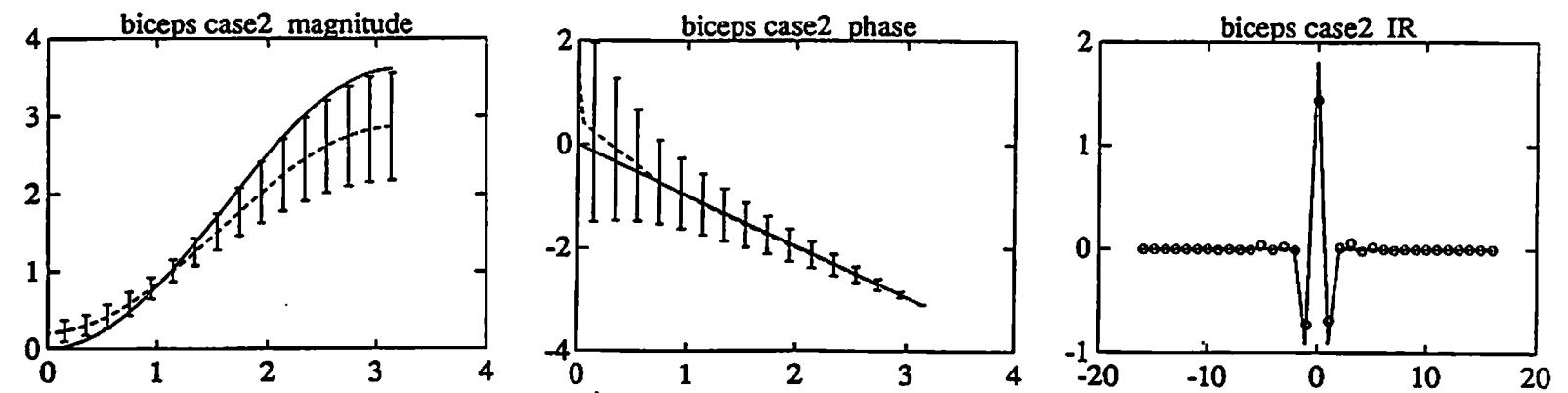
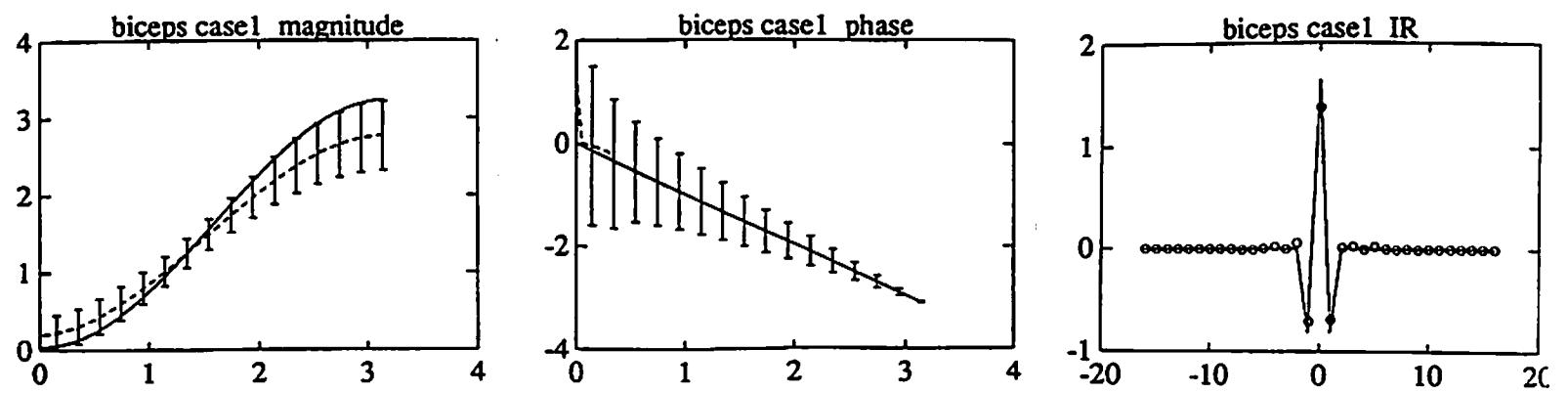
GM+T case36 IR

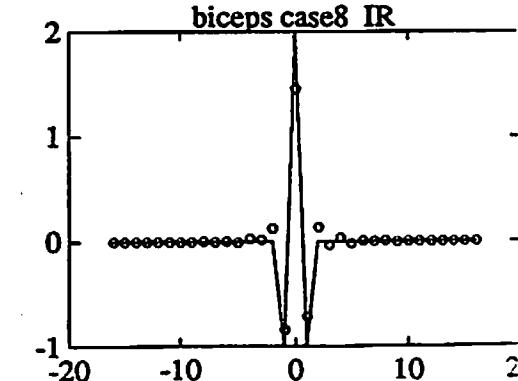
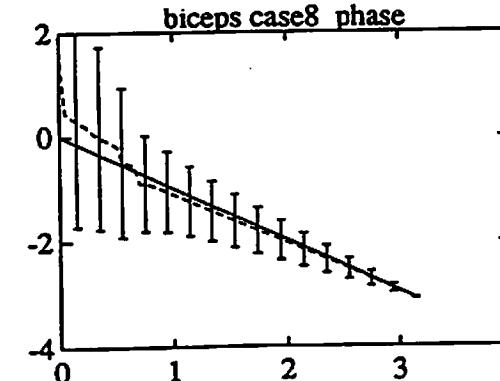
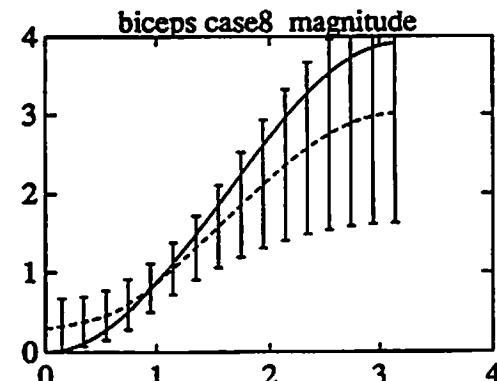
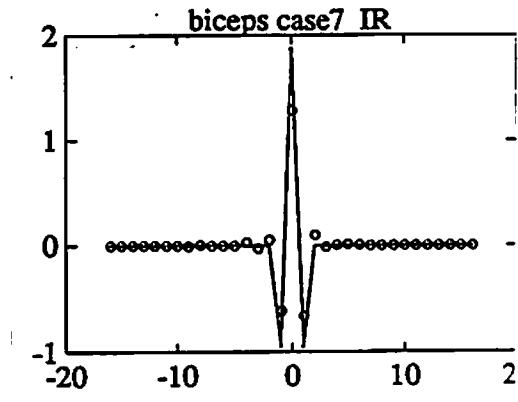
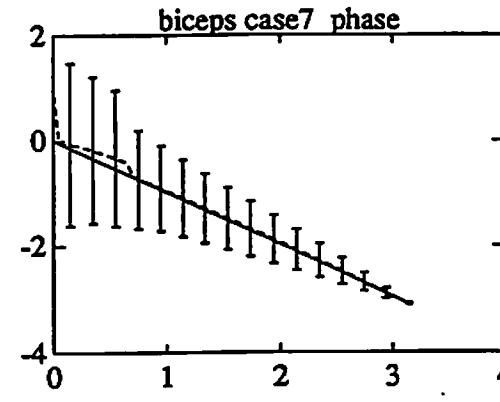
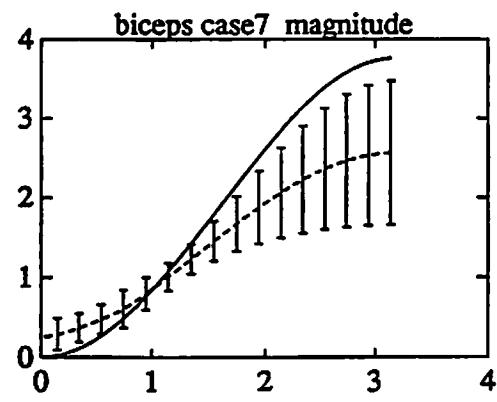
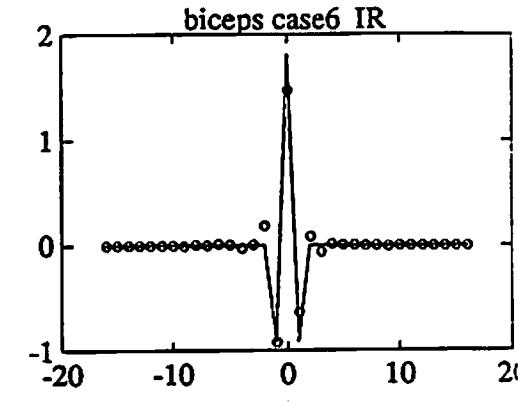
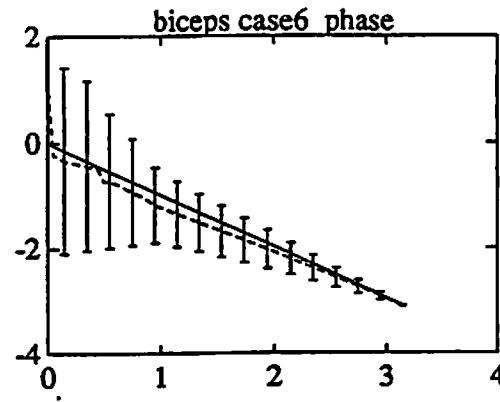
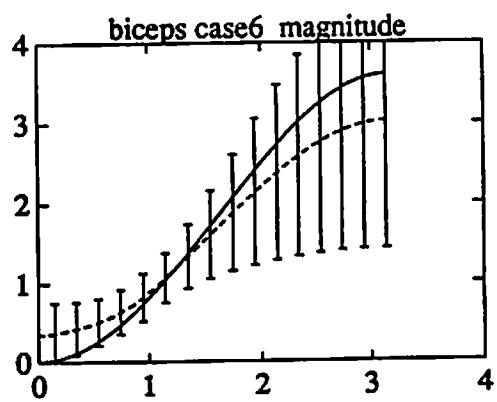
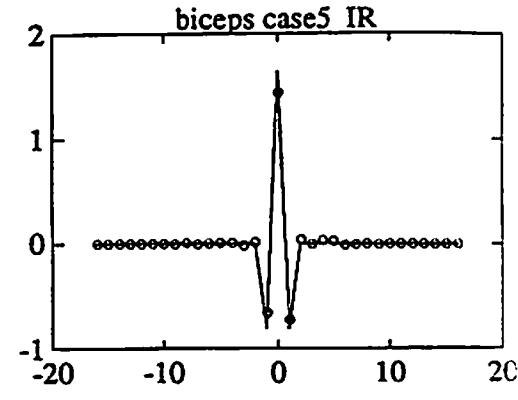
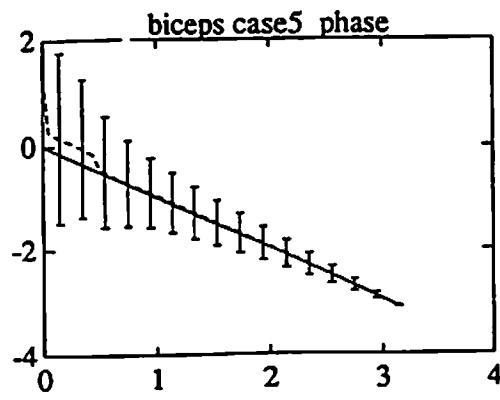
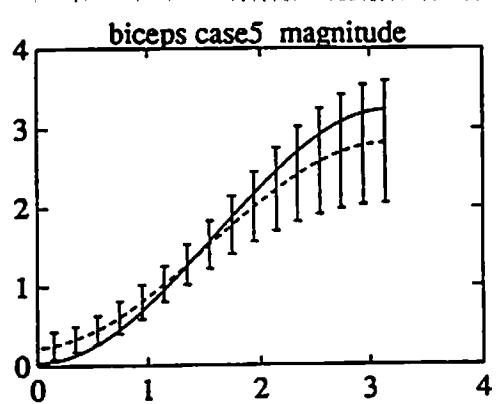


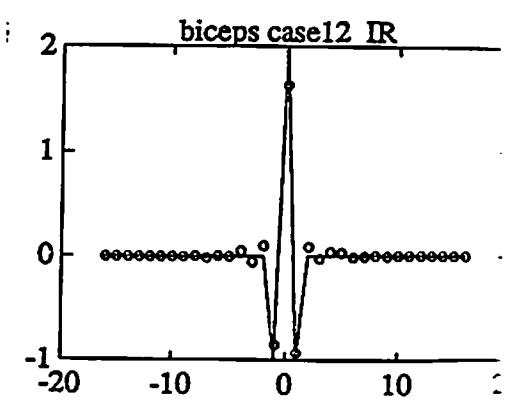
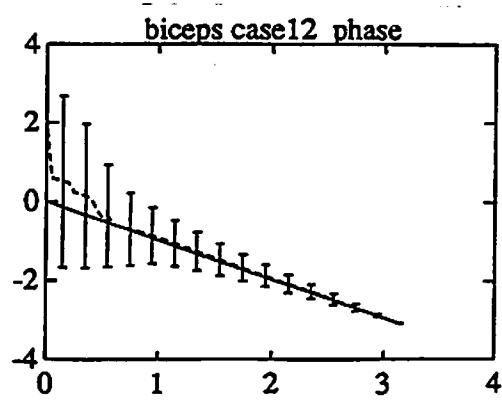
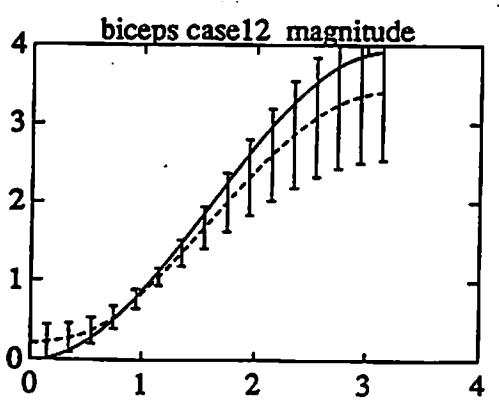
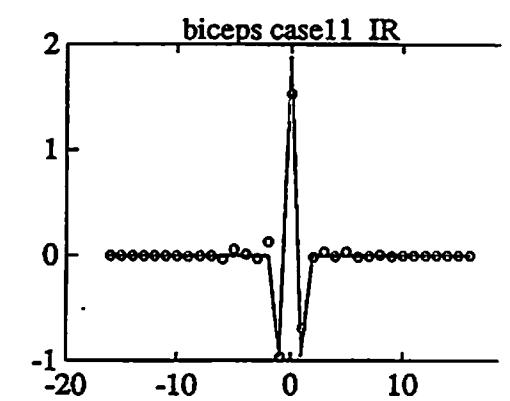
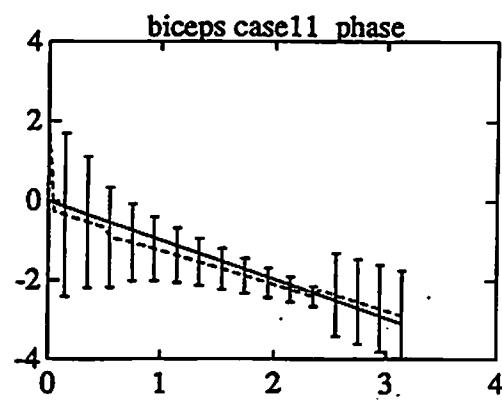
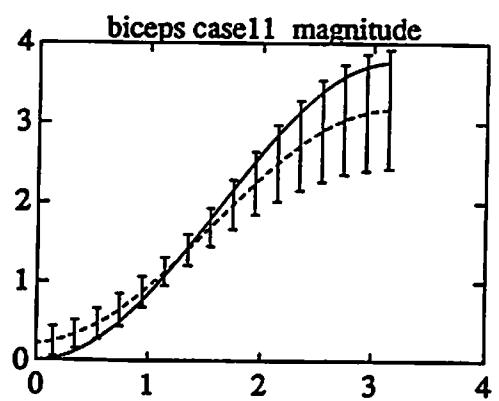
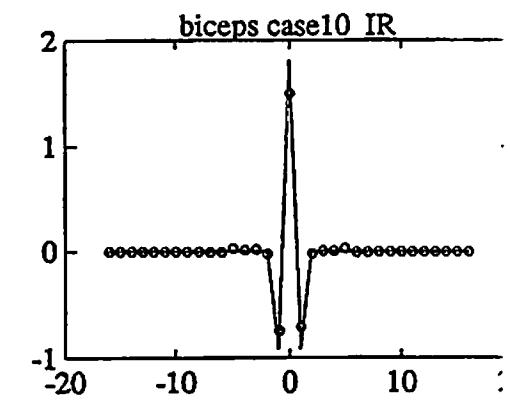
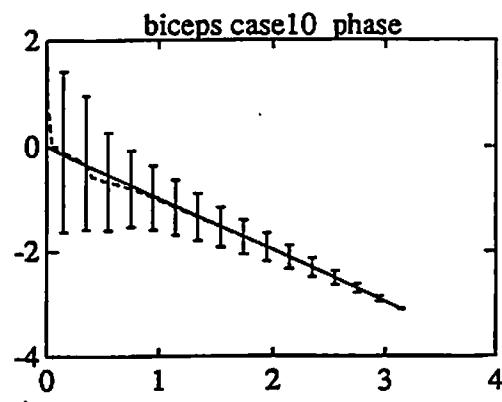
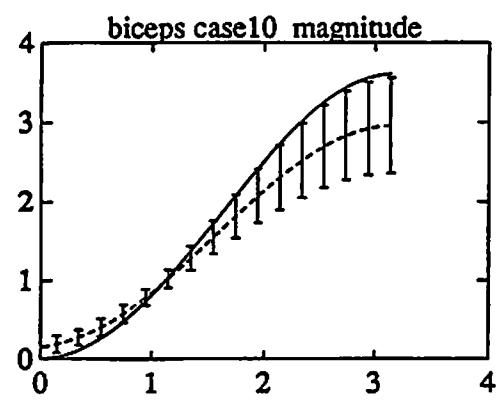
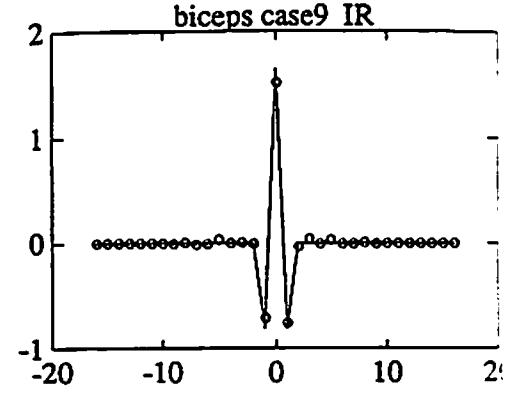
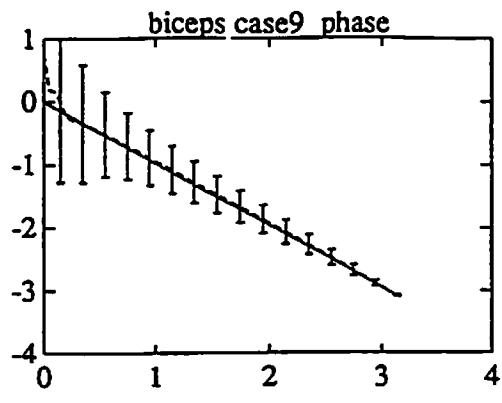
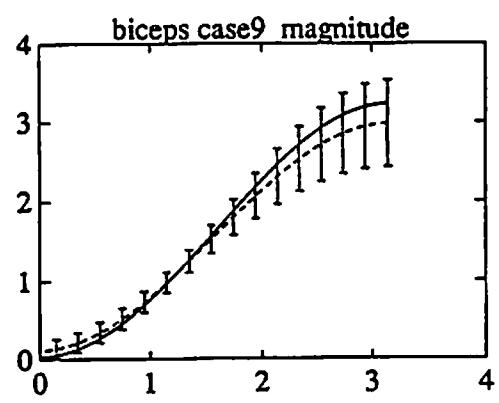




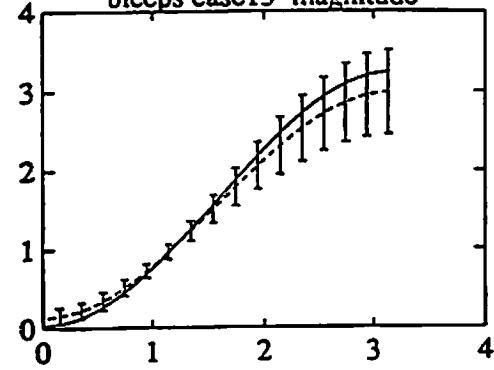




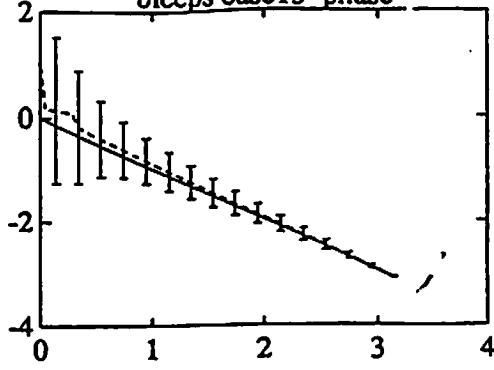




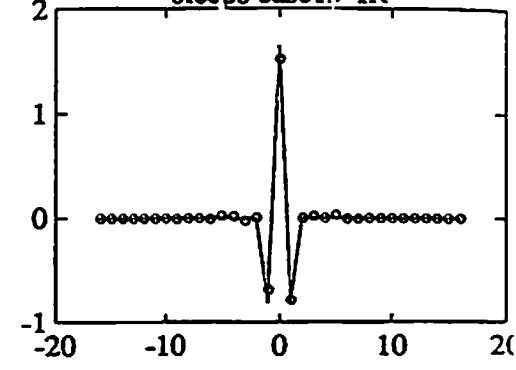
biceps case13 magnitude



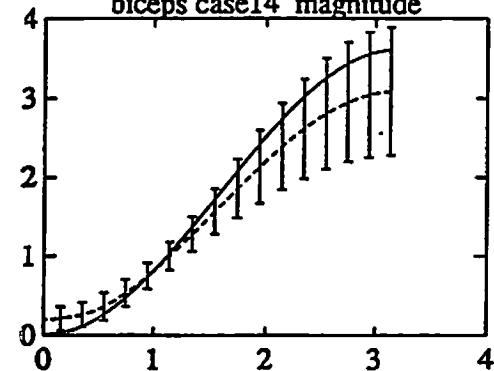
biceps case13 phase



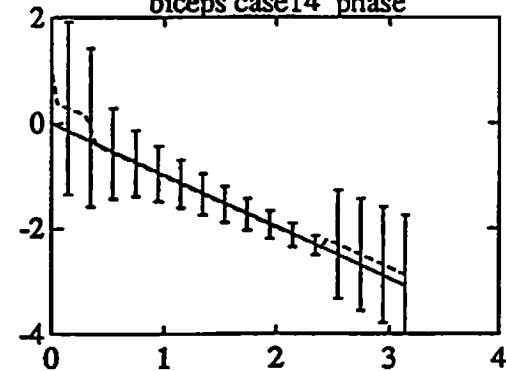
biceps case13 IR



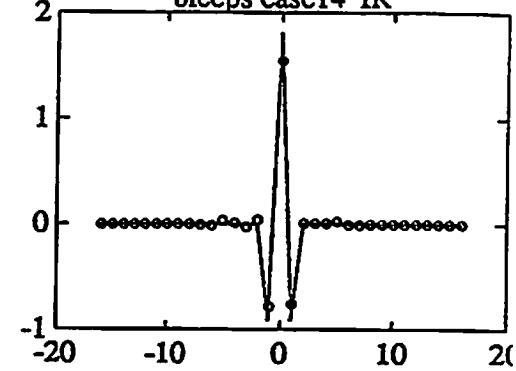
biceps case14 magnitude



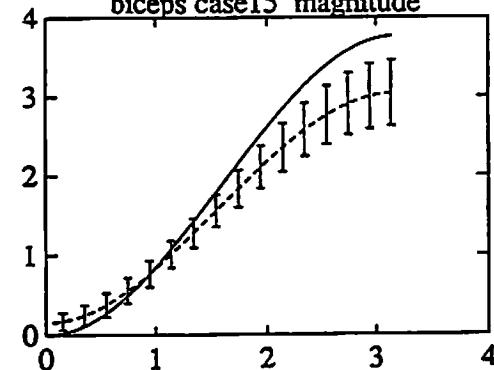
biceps case14 phase



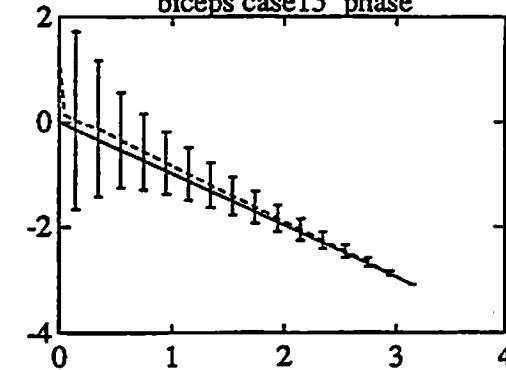
biceps case14 IR



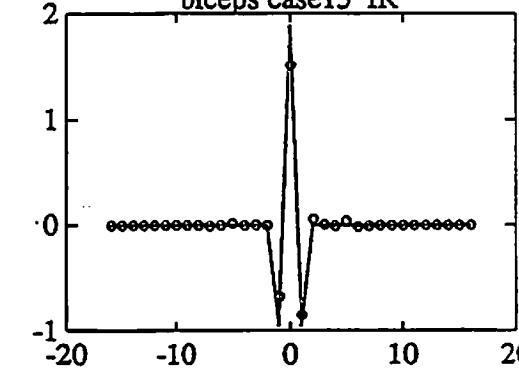
biceps case15 magnitude



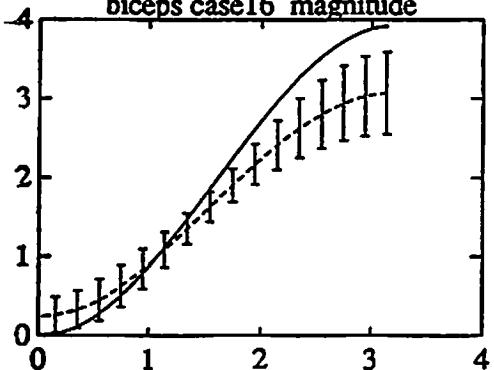
biceps case15 phase



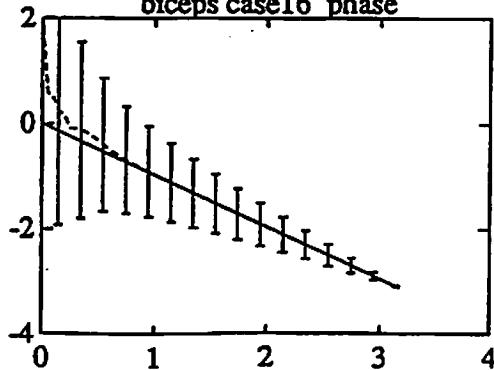
biceps case15 IR



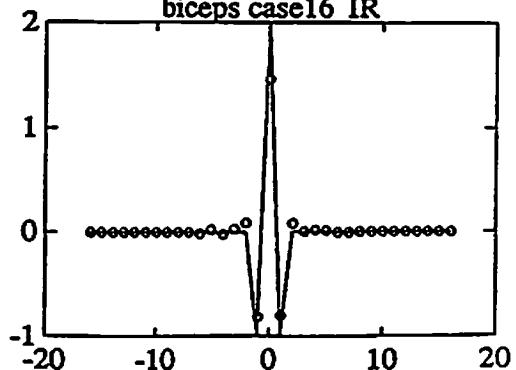
biceps case16 magnitude

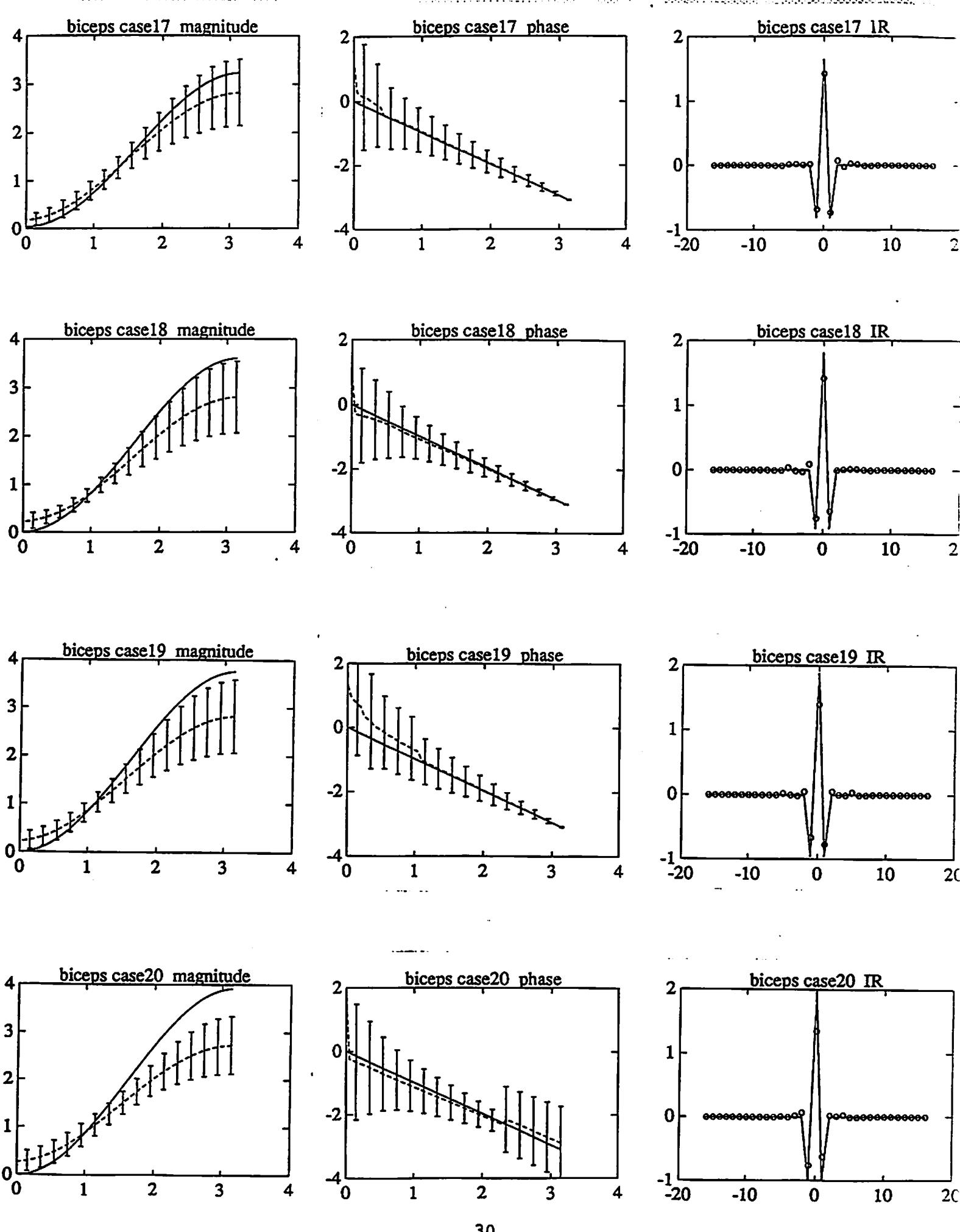


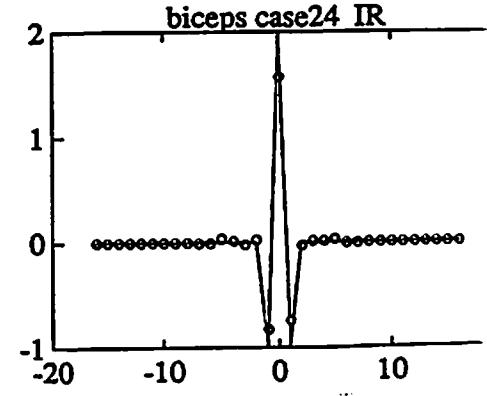
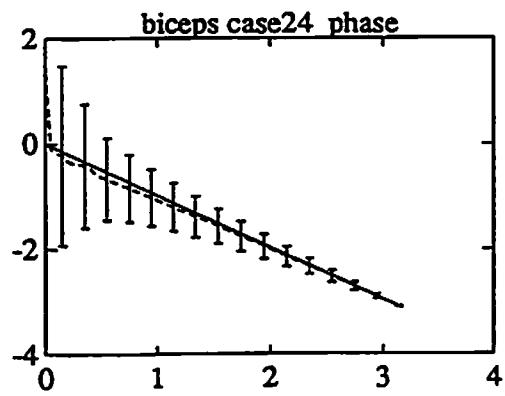
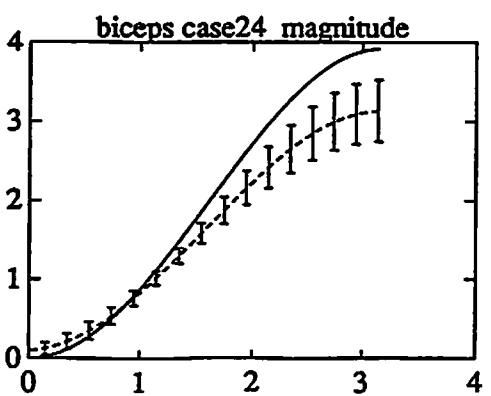
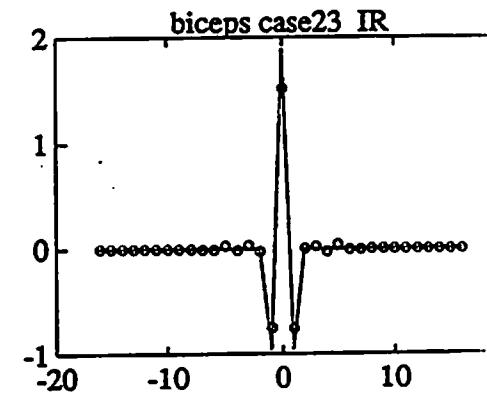
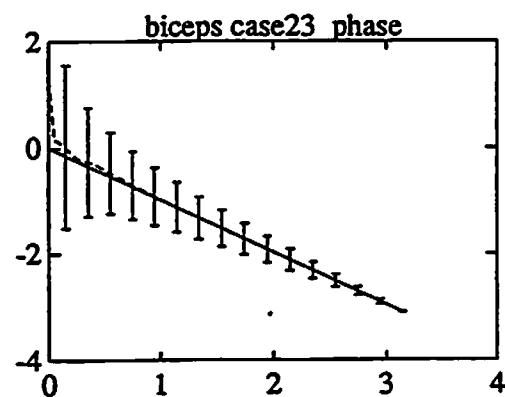
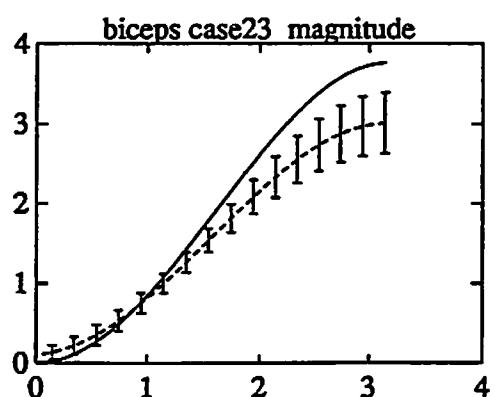
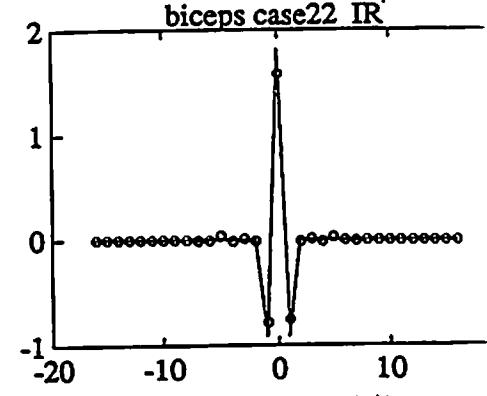
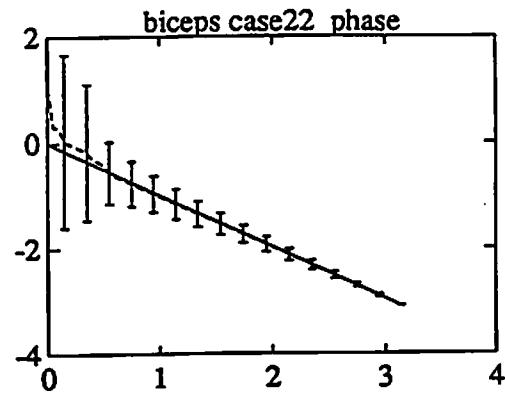
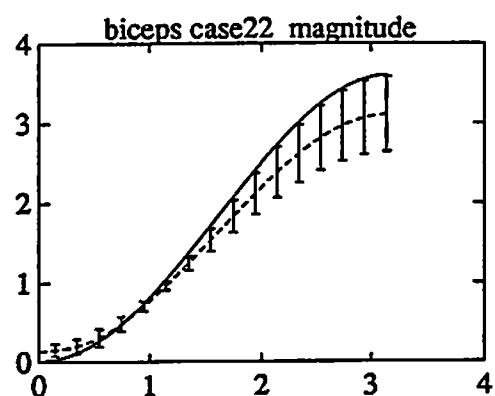
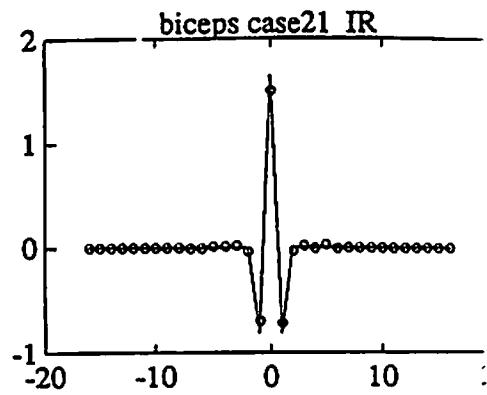
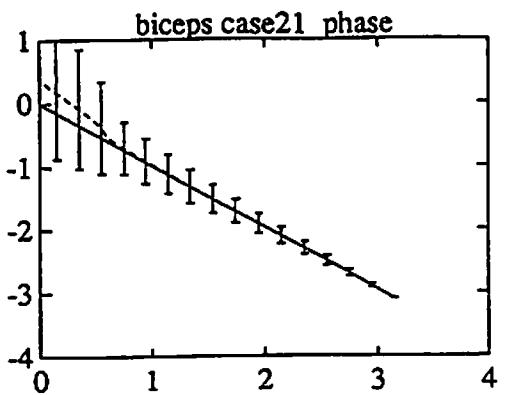
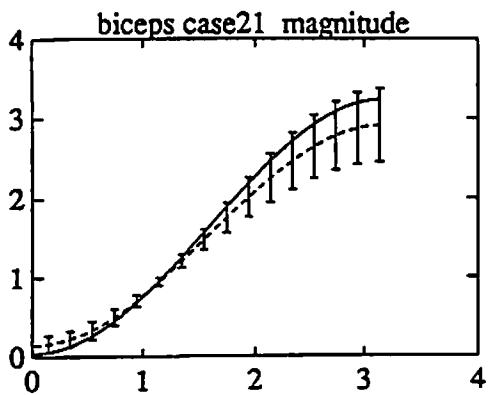
biceps case16 phase

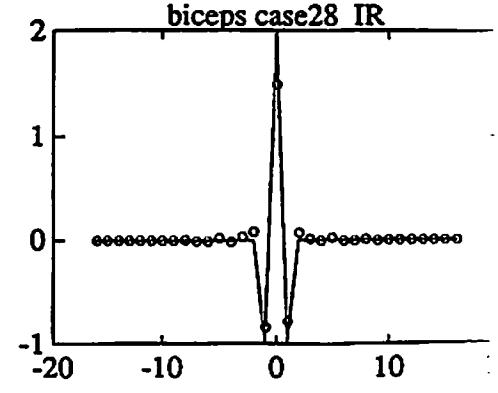
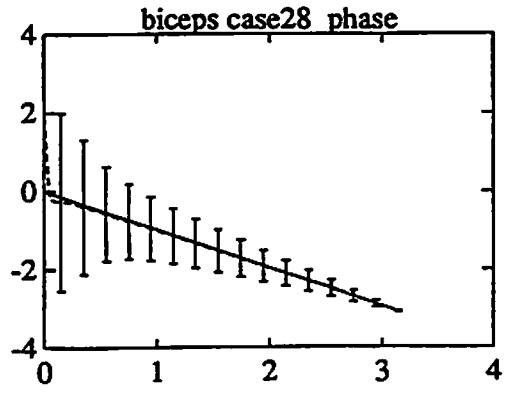
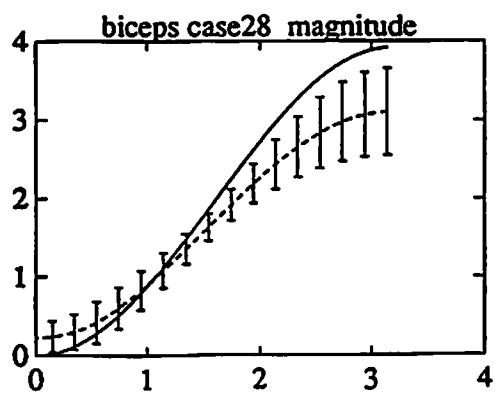
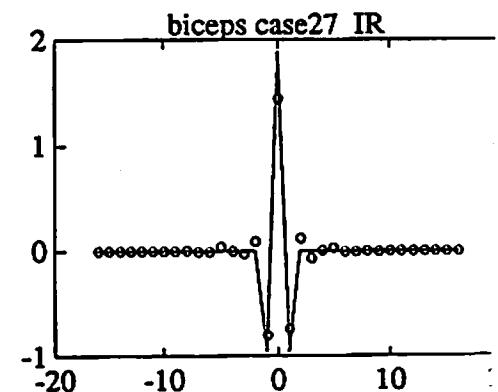
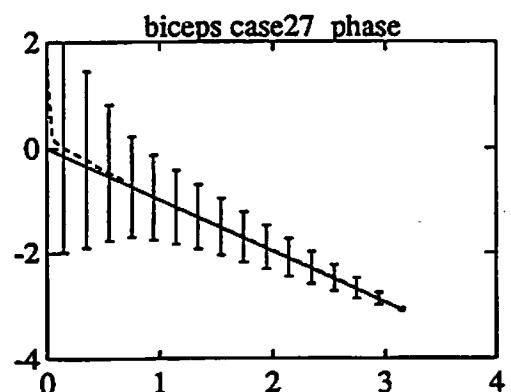
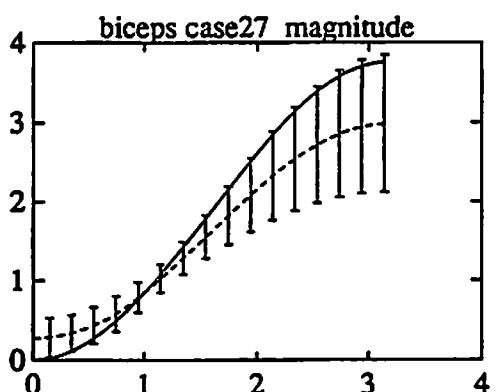
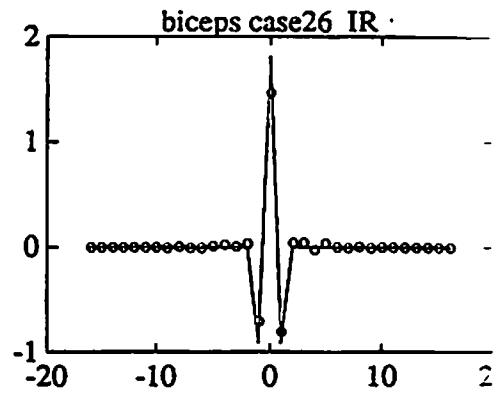
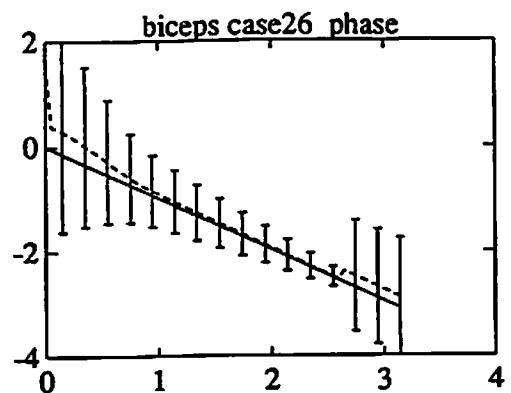
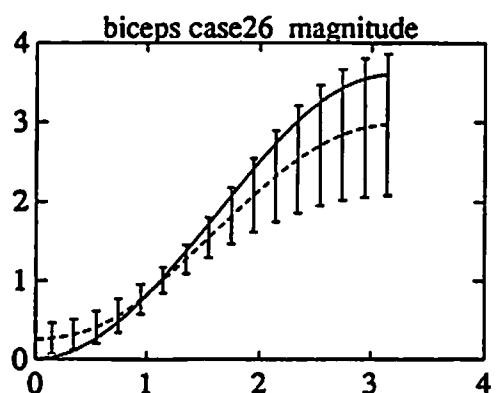
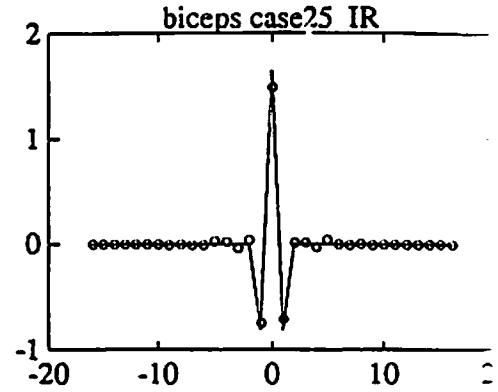
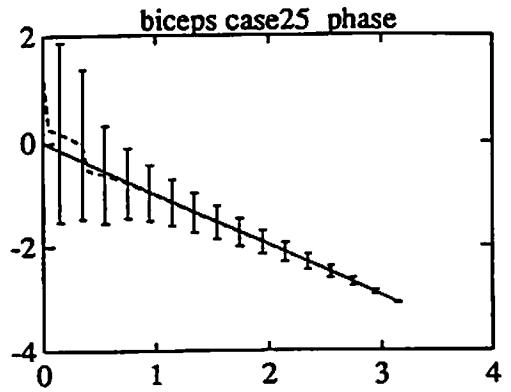
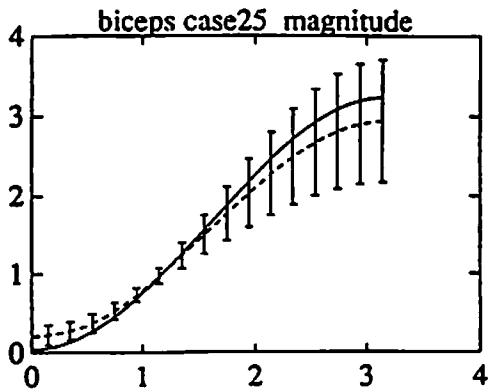


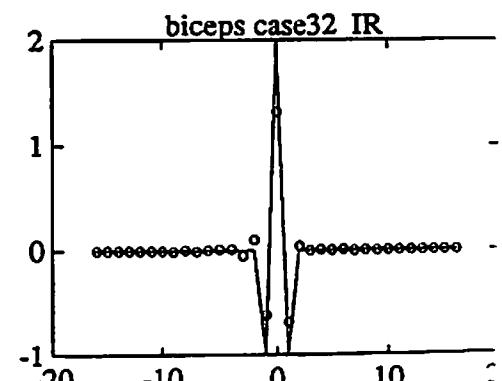
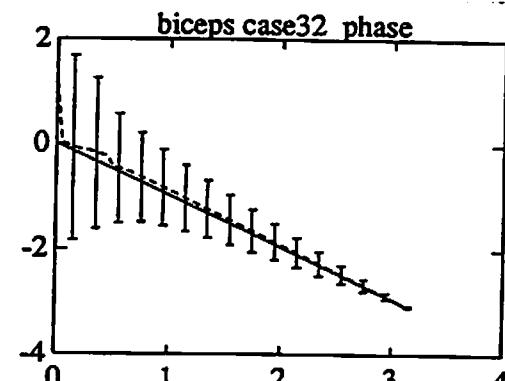
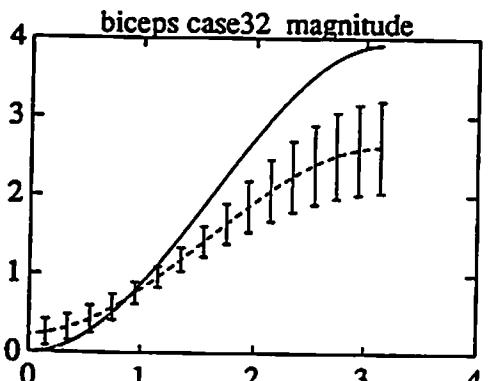
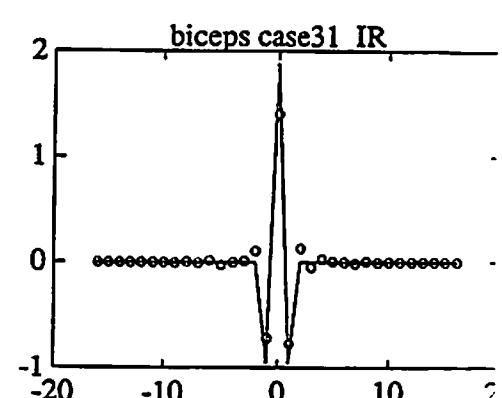
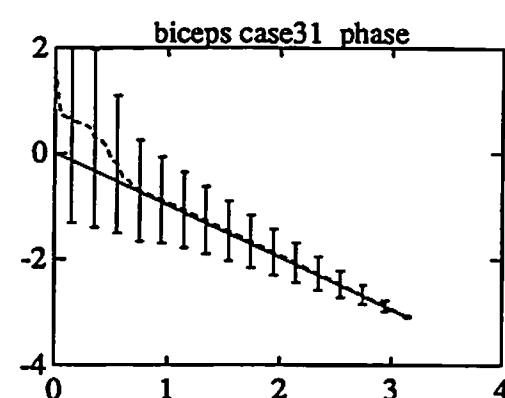
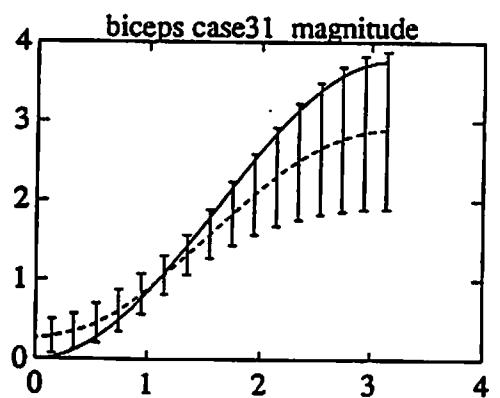
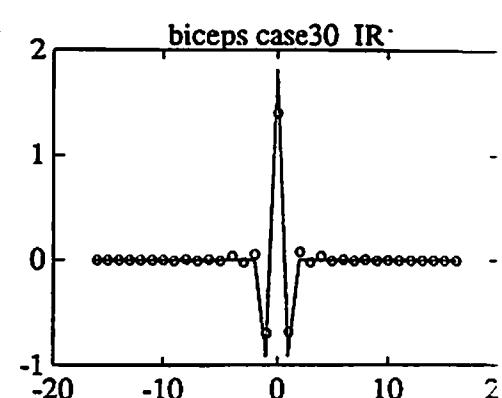
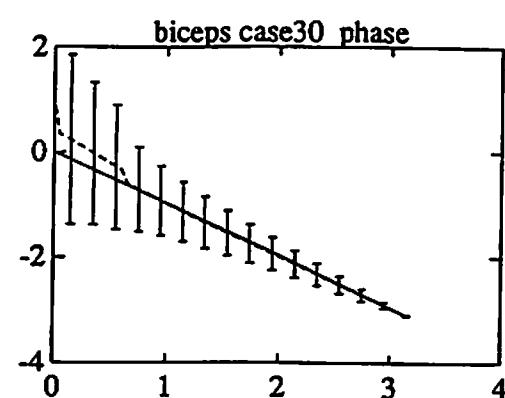
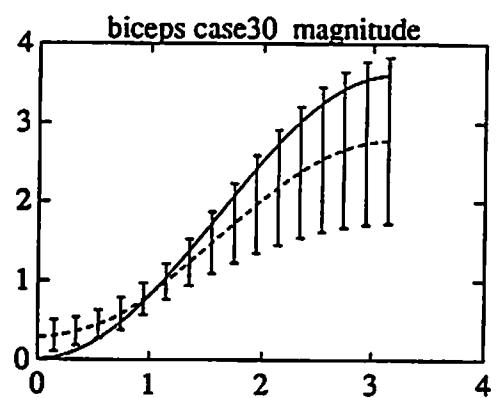
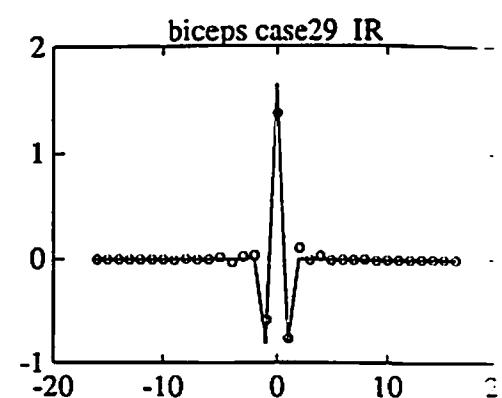
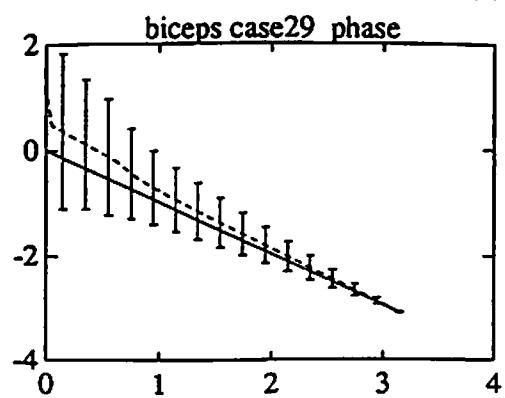
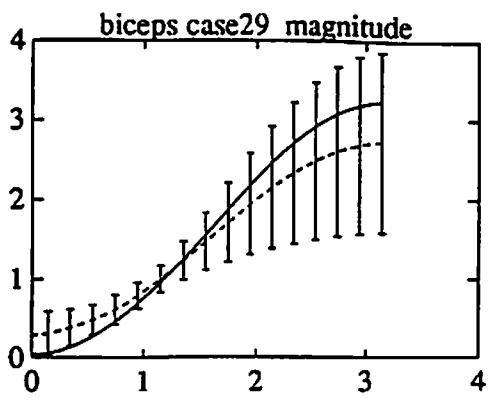
biceps case16 IR

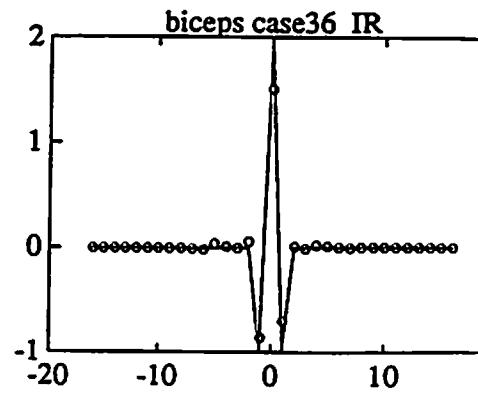
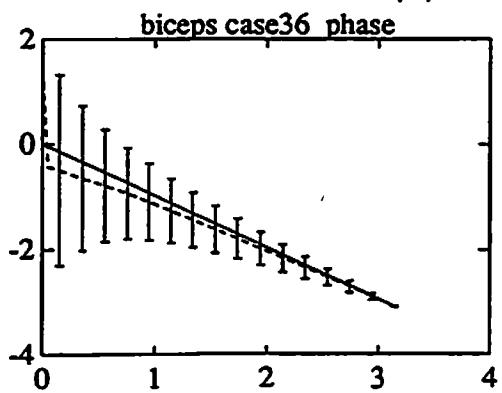
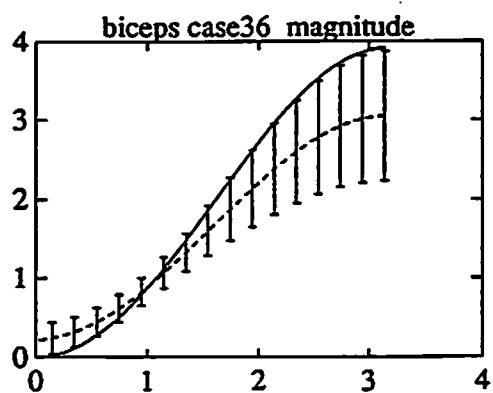
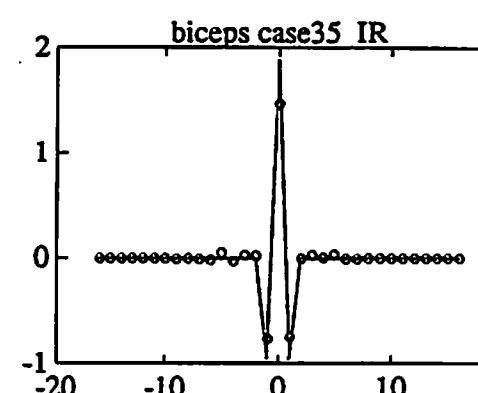
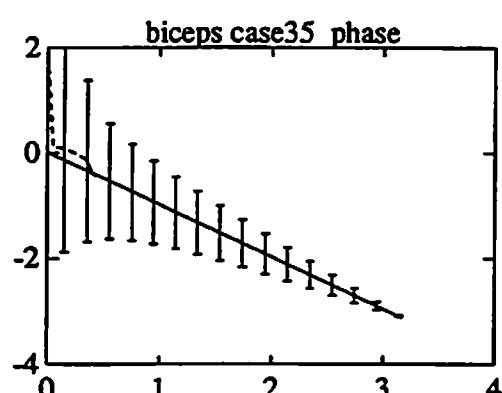
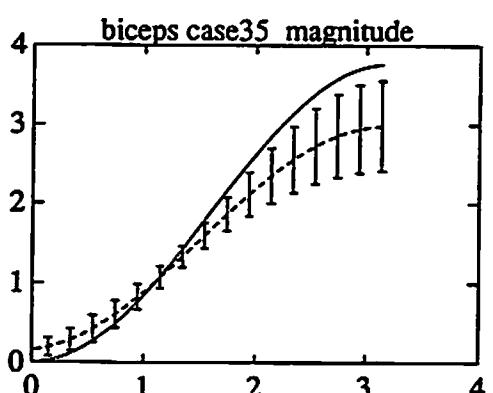
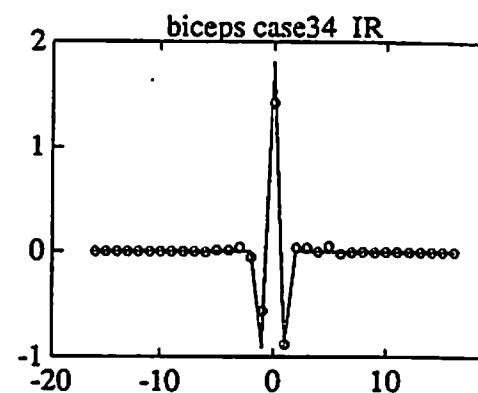
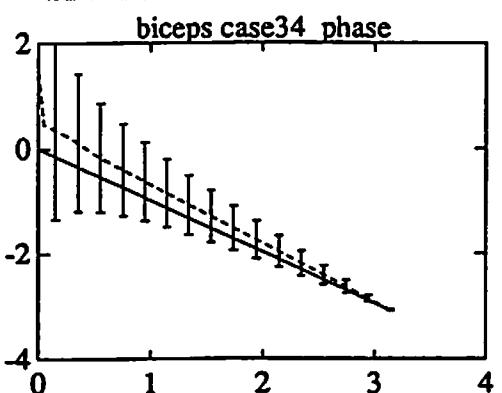
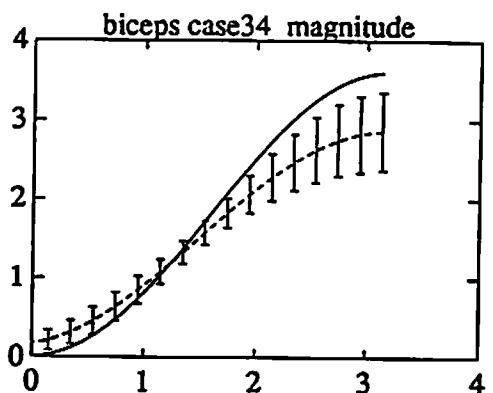
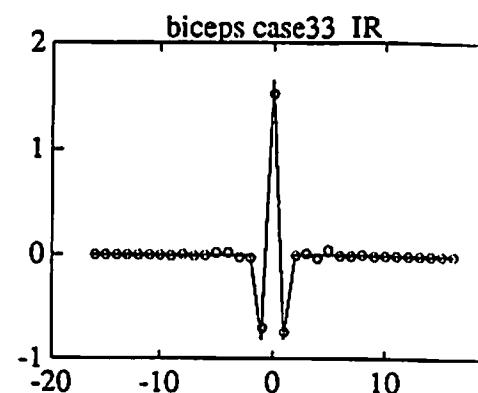
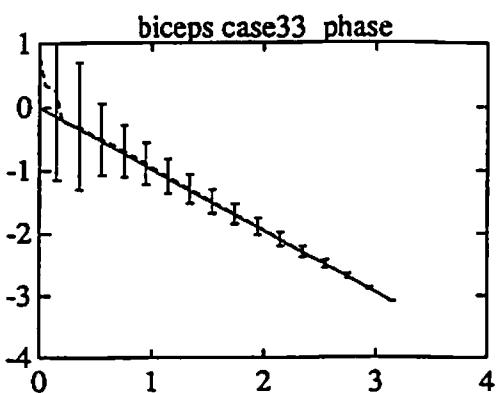
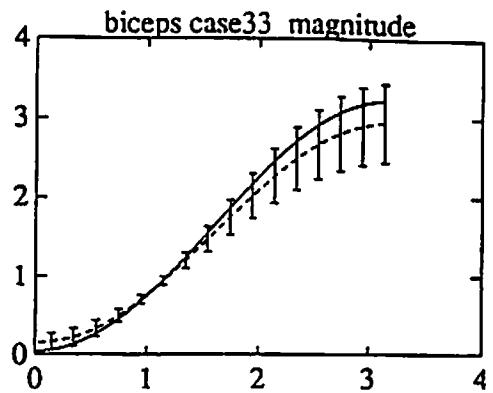


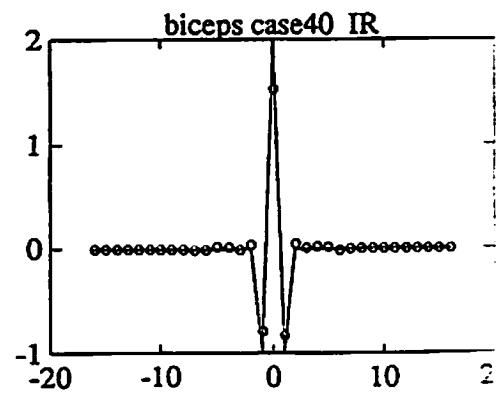
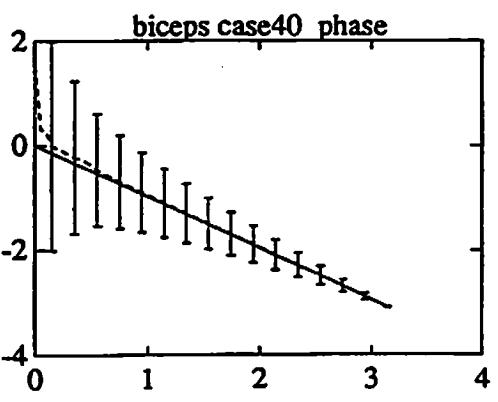
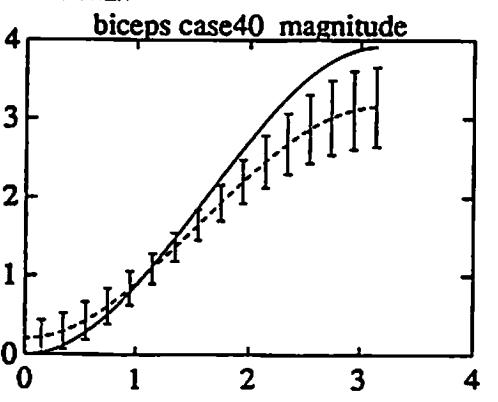
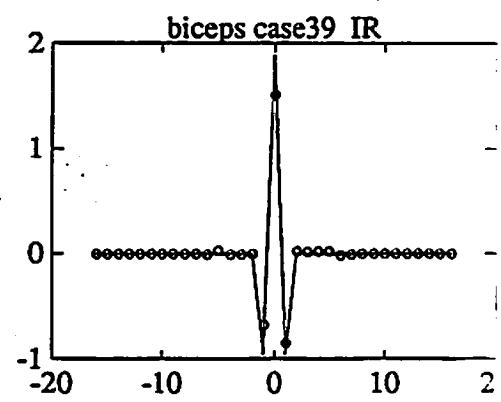
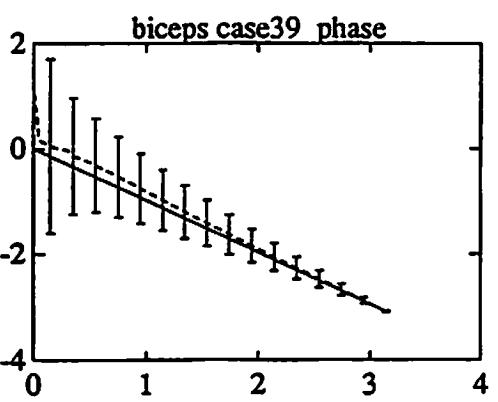
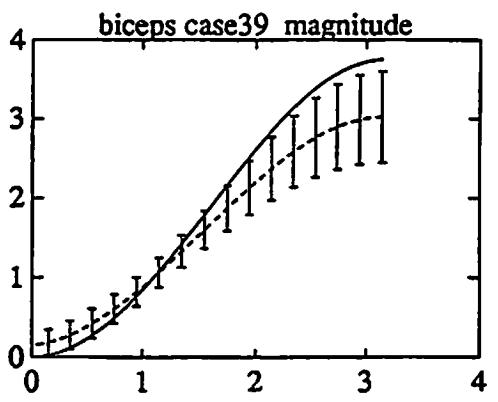
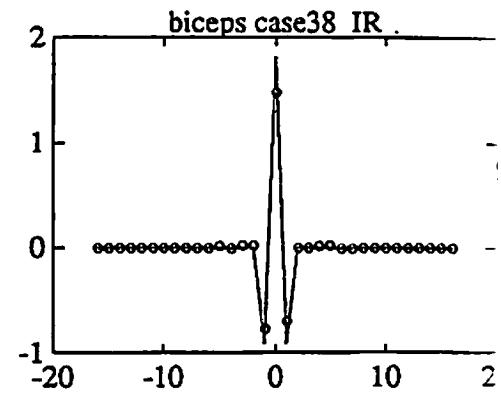
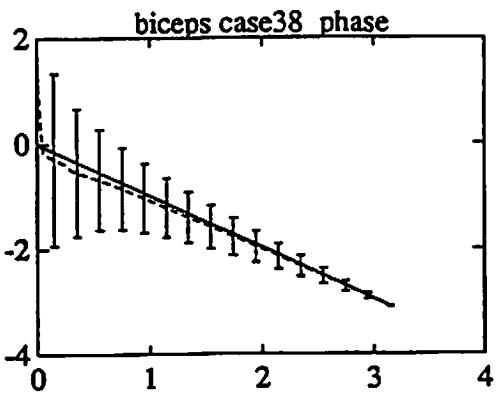
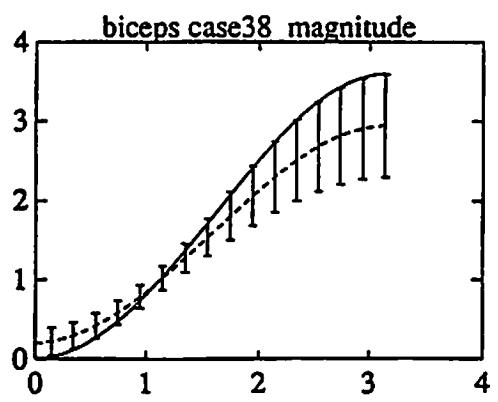
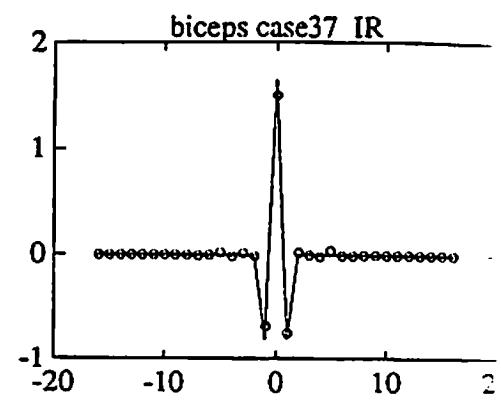
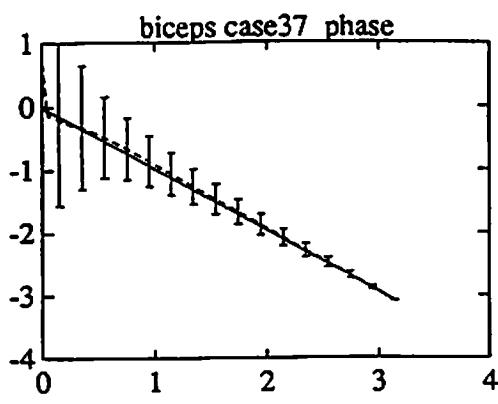
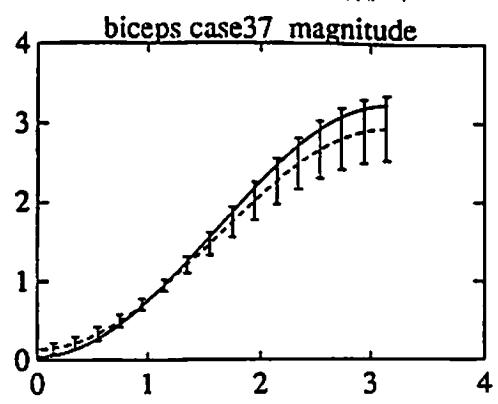




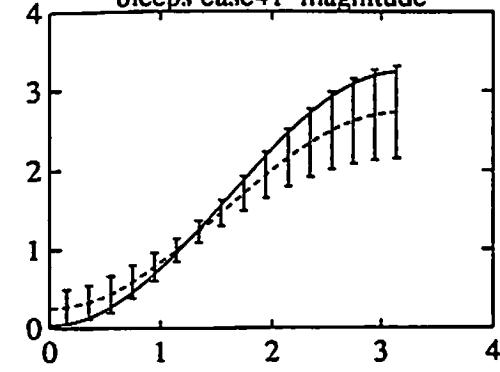




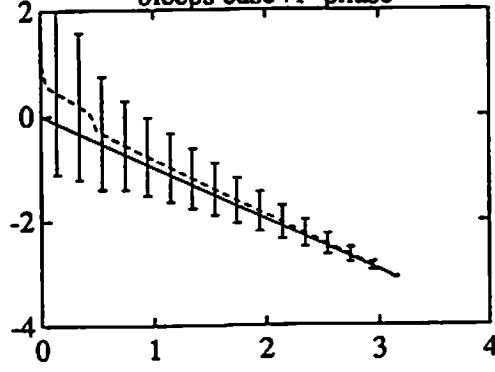




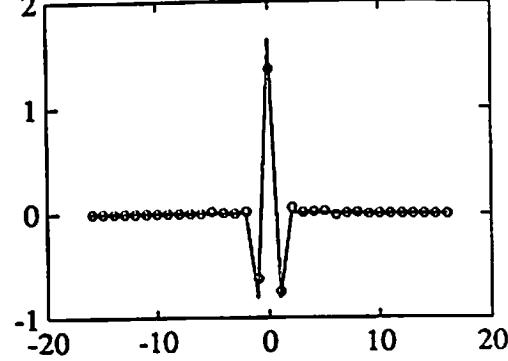
biceps case41 magnitude



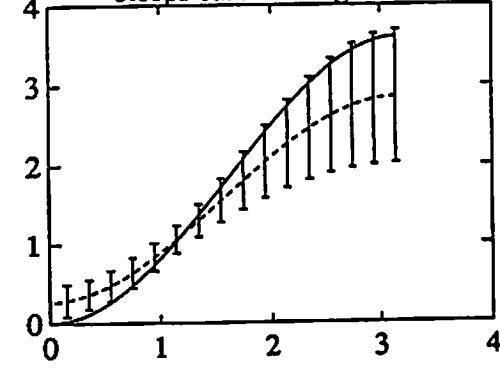
biceps case41 phase



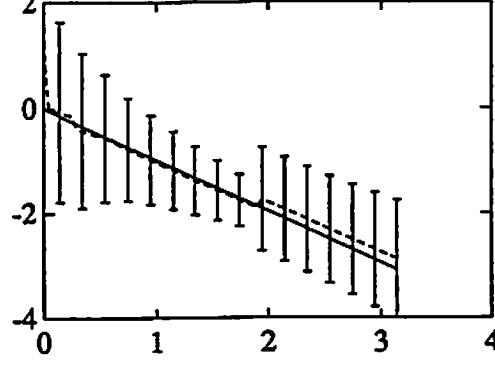
biceps case41 IR



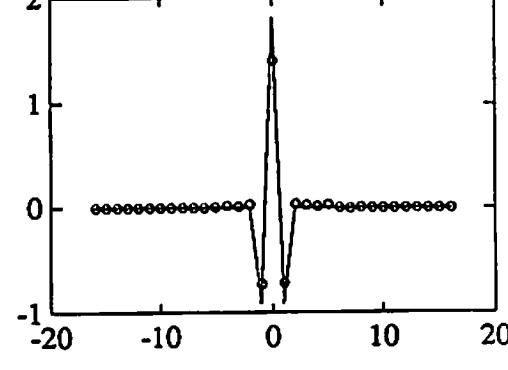
biceps case42 magnitude



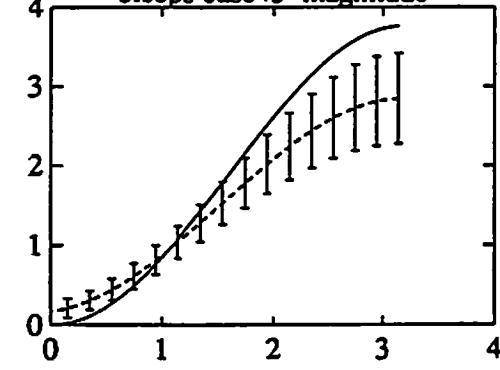
biceps case42 phase



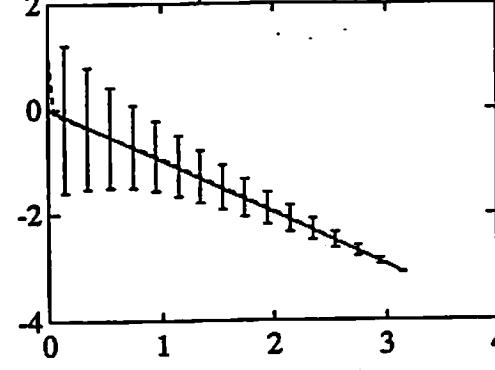
biceps case42 IR



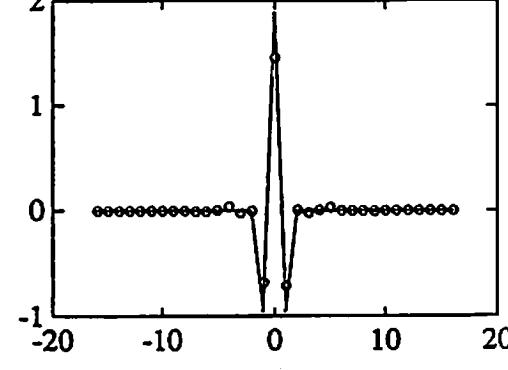
biceps case43 magnitude



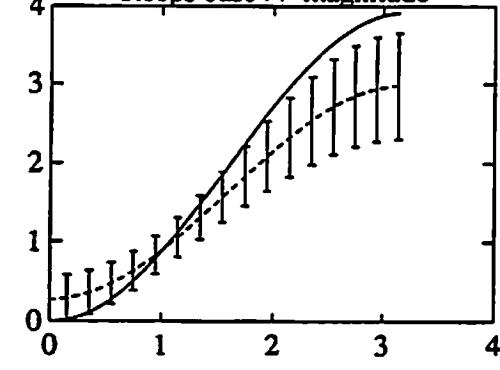
biceps case43 phase



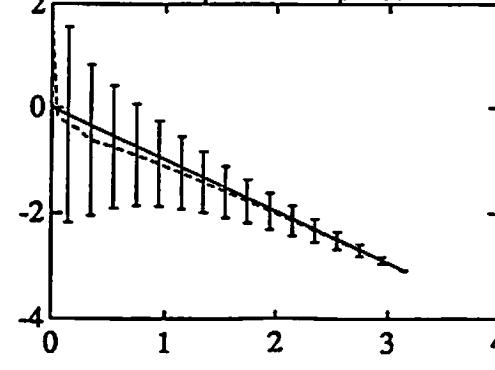
biceps case43 IR



biceps case44 magnitude



biceps case44 phase



biceps case44 IR

