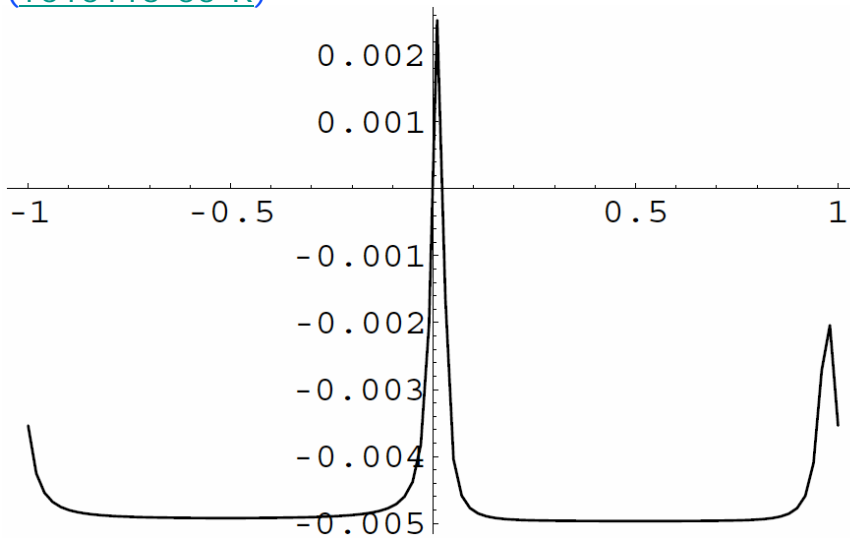


Effect of sideband of sideband on 40m and Advanced LIGO

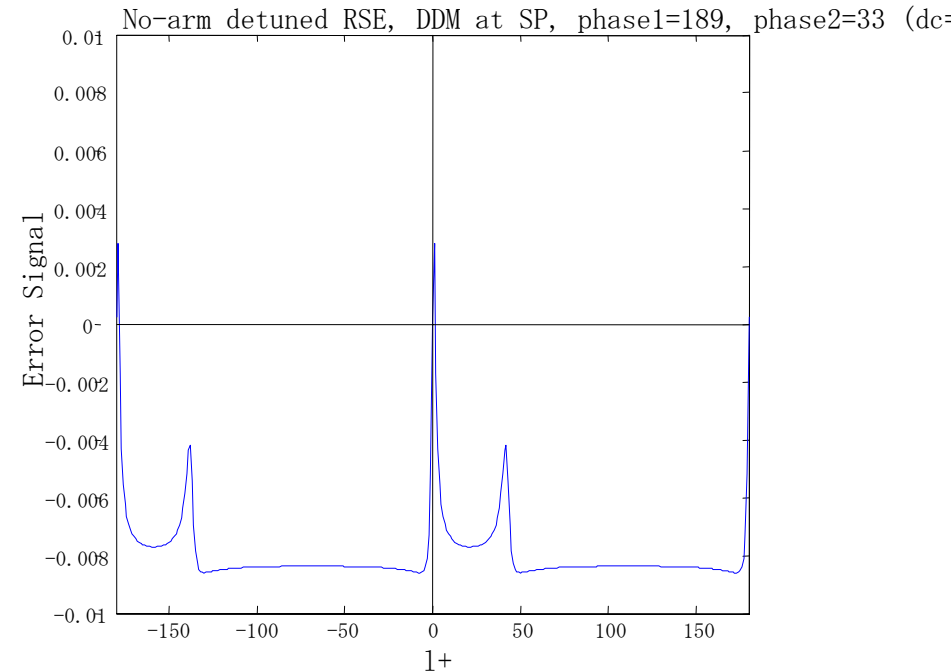
Osamu Miyakawa, Caltech

LIGO-G040311-00-R

I+ signal calculated by Twiddle on Conceptual Design of the 40 meter Conceptual Design of the 40 meter (T010115-00-R)



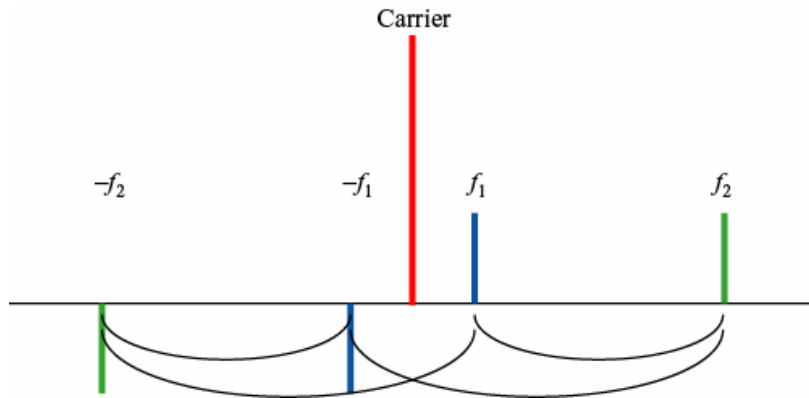
I+ signal Calculated by FINESS



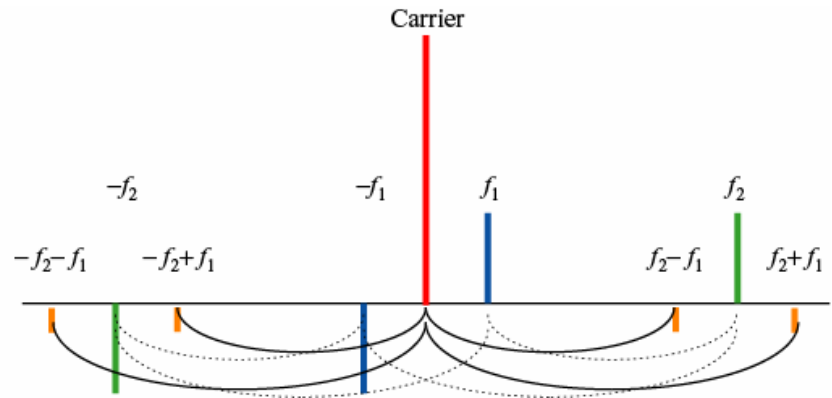
- I+ signal of DDM has a big offset when it is not resonant in both cases.
- However **no offset** on real signal at all.

Sideband of sideband

Simulation

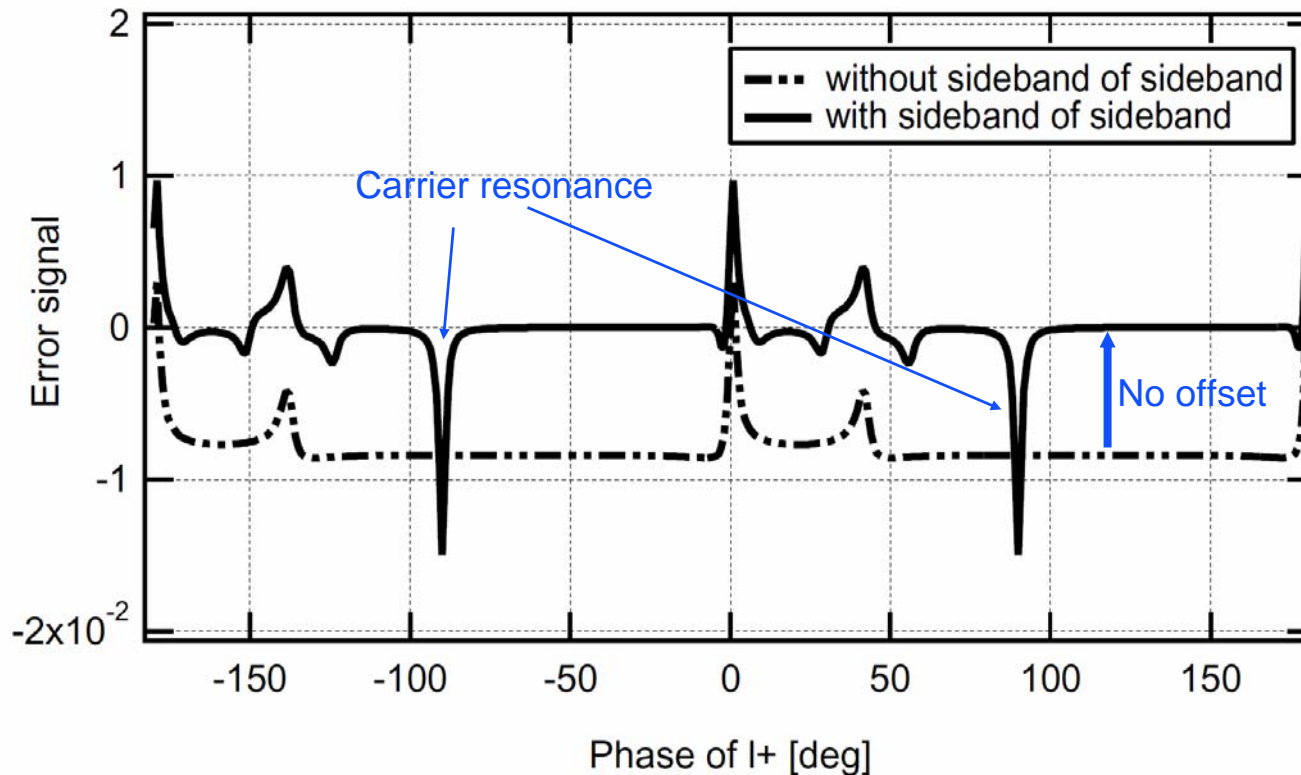


Real world



- 166MHz Sideband is produced on existing 33MHz sideband with two serial EOM.
- Sideband of sideband is amplitude modulation with 180degree phase offset against carrier.
- Beat between carrier and $f_2 \pm f_1$ produces signal with unbalanced sideband by detuned cavity.

I+ signal with sideband of sideband



- No offset
- Big disturbance by carrier
- Some small disturbance

Signal matrix

- Original signal matrix

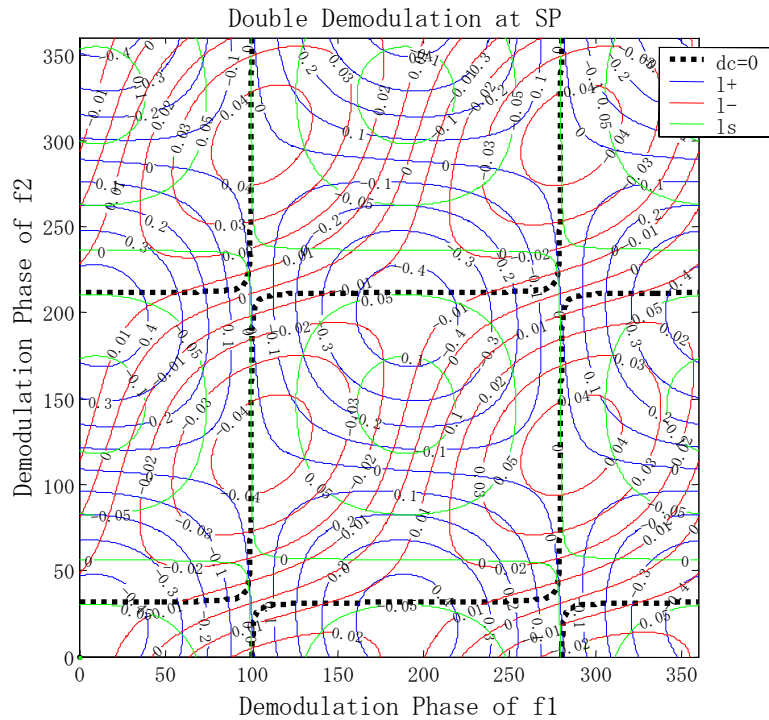
Port	Dem. freq.	Dem. phase	L_+	L_-	l_+	l_+	L_s
SP	f_1	10	1	-3.8E-9	-1.2E-3	-1.3E-6	-2.3E-6
AP	f_2	271	-4.8E-9	1	-1.2E-8	-1.3E-3	-1.7E-8
SP	$f_1 \times f_2$	189,32	-1.7E-3	-3.0E-4	1	-3.2E-2	-1.0E-1
AP	$f_1 \times f_2$	4,81	-6.2E-4	1.5E-3	7.5E-3	1	7.1E-2
PO	$f_1 \times f_2$	164,12	3.6E-3	2.7E-3	4.6E-1	-2.3E-2	1

- Signal matrix with sideband of sideband

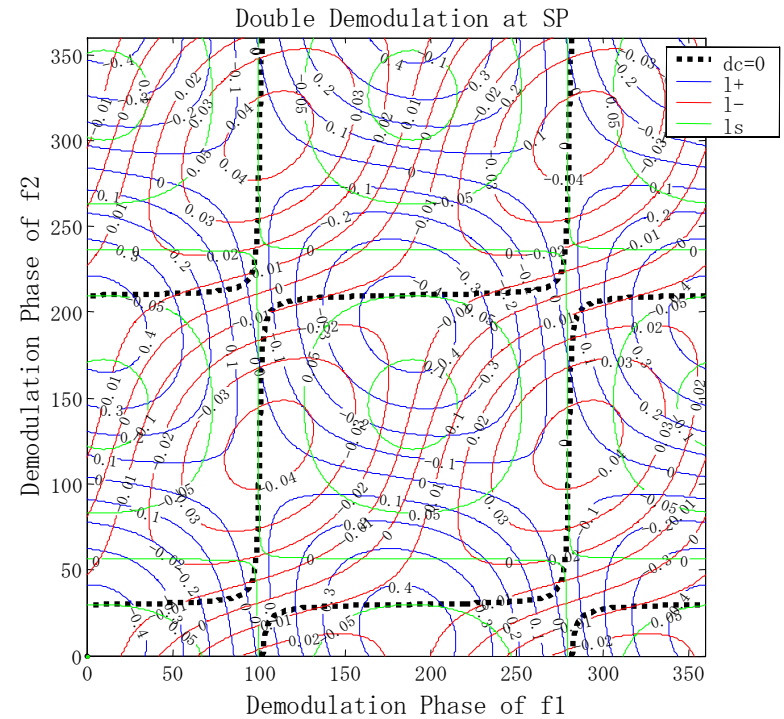
Port	Dem. freq.	Dem. phase	L_+	L_-	l_+	l_+	L_s
SP	f_1	10	1	-1.4E-8	-1.2E-3	-1.4E-6	-6.2E-6
AP	f_2	271	1.2E-7	1	1.4E-5	1.3E-3	6.5E-6
SP	$f_1 \times f_2$	184,30	7.4	-3.4E-4	1	-3.3E-2	-1.1E-1
AP	$f_1 \times f_2$	4,73	-5.7E-4	32	7.1E-1	1	7.1E-2
PO	$f_1 \times f_2$	161,4	3.3	1.7	1.9E-1	-3.5E-2	1

SP contour plot for I+ signal

No sideband of sideband



With sideband of sideband

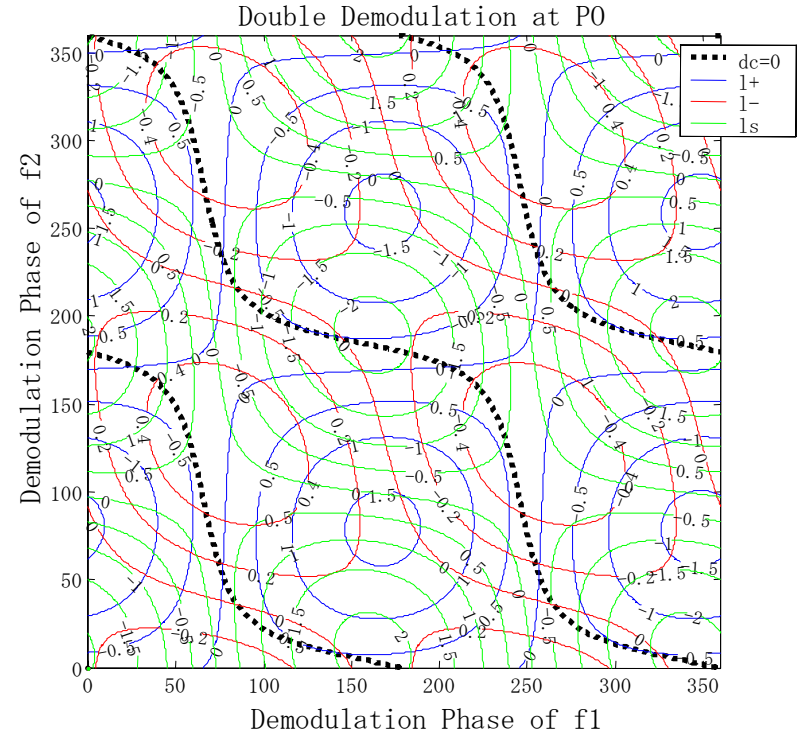
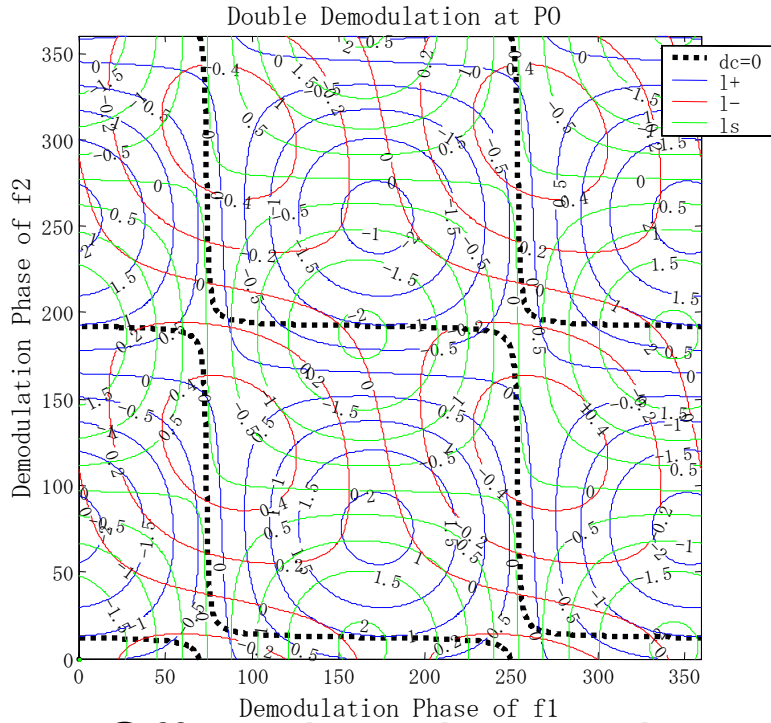


- No big difference?

PO contour plot for Is signal

No sideband of sideband

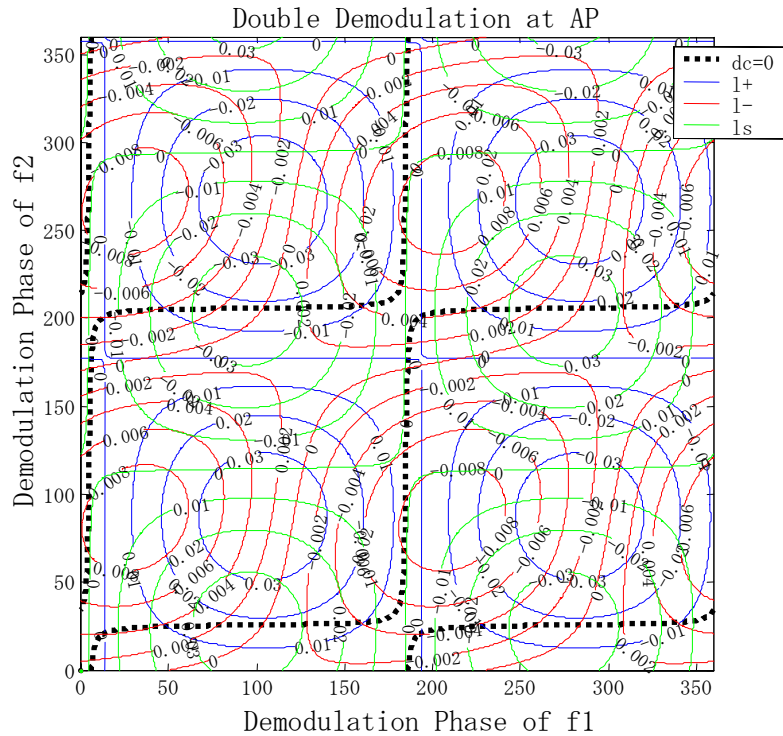
With sideband of sideband



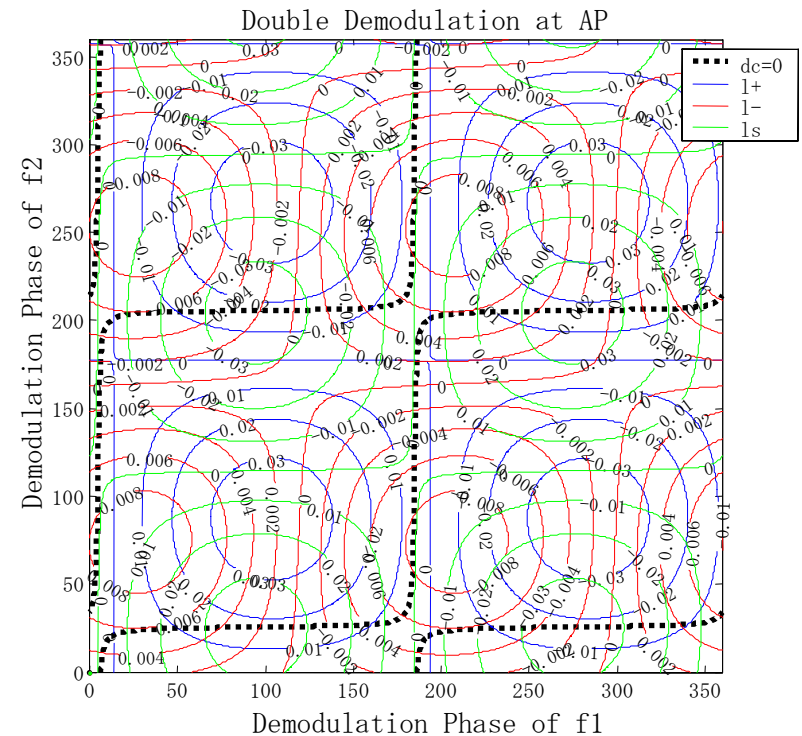
- Offset line changed.

AP contour plot for I- signal

No sideband of sideband



With sideband of sideband



- No big difference

Summary

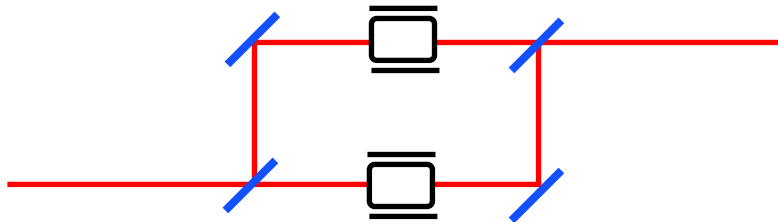
- Sideband of sideband was not discussed when 40m and AdLIGO were designed.
- Sideband of sideband introduce a new disturbance because of the beat between carrier and $f1 \pm f2$
- Signal matrix is worse than before.
- Lock acquisition problem
 - » Carrier resonance of PRC and SEC
 - » Carrier resonance of the arm

What should we do?

- Continue this optical setting with sideband of sideband?
- Change experimental setup to avoid sideband of sideband?

To avoid sideband of sideband

- Mach Zender interferometer
 - » One more control
 - » Mode matching, same length, Alignment again



- 2 more EOM to kill 133MHz and 199MHz
 - » Need to adjust phase and amplitude
- Apply Voltage to existing EOM with 133MHz and 199MHz to kill sideband of sideband
 - » Need to adjust phase and amplitude
 - » Using resonant type EOM??