NATIONAL RADIO ASTRONOMY OBSERVATORY

TUCSON, ARIZONA

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To: 36-Foot Telescope Spectral Line Observers

From: R. Howard

Subject: CO Spectral Line Calibration with new Fabry-Perot Filter

Prior to April, 1979 the only Fabry-Perot filter available had meshes (BTL) with a mesh period(P) of 2.11 mm. This filter did not have ideal rejection at 12CO or even 13CO. Thus the TC(SSB) values used had to be increased (see ULICH, B.L., NRAO MEMO, March 3, 1977, "Accuracy of Spectral Line Intensity Calibration with Cassegrain Receiver").

A new Fabry-Perot filter is now available (since September, 1979) which has been specifically designed (P=1.98 mm) for ^{12}CO , ^{13}CO and ^{C18}O . The filter can be installed in or removed from the quasi-optics box in 15-20 minutes by the operator. Table I gives the insertion loss at the sky frequency (USB), isolation of the image frequency (LSB) and the gain ratio of the filter (G_i/G_s). The isolation is the insertion loss at the image frequency minus the insertion loss at the signal frequency.

USB SIGNAL FREQUENCY (GH _Z) LINE	115.27 12 _{C0} 110.2/109.8 13 _{C0/C} 18 ₀
INSERTION LOSS (dB)	0.50 0.65
ISOLATION OF LSB (dB)	21.5 23.8
G _i /G _s of filter	0.007 0.004

TABLE I: CO FILTER #1 (P=1.98 mm)

Using the values for G_1/G_S listed in Table I one can calculate the TC(SSB) values that should be used at 12_{CO} , 13_{CO} and $C^{18}O$. However, since the quasi-optics box reduces the amplitude of the spectral line vane calibration signal, the calculated TC values must be reduced by 7% (See ULICH, B.L., NRAO MEMO, September 18, 1979, "Calibration with Quasi-Optics Box Installed"). Table II lists the calculated values of TC for frequencies in the 80-115 GH_Z range. The TC(DSB) values are calculated for receiver gain ratio (G_1/G_S) of 1.0. In general the receiver G_1/G_S is not exactly 1.0 and will depend on the diodes used and how they are tuned. For the TC(SSB) values in the 80-105 GH_Z range, the image rejection was assumed to be perfect ($G_1/G_S = 0$). This is not true for all

frequencies in that range. To determine to correct G_i/G_s , one should look at the Isolation/Insertion loss curves for the image rejection filter being used.

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Frequency (GH_)	80-105	110	,115
Spectral Line(s)	HCN, HCO ⁺ , CS, etc.	$13_{CO}, C^{18}_{O}$	¹² co
G Control (With Filter)*	0.000	0.004	0.007
: _s Nepers)	0.080	0.120	0.350
: _i (Nepers)	0.080	0.075	0.085
CAL	CULATED VALUES OF TC USING IMAG	GE REJECTION FILTER*	
LEVATION	TC(SSB)	TC(SSB)	TC(SSB)
90	367	369	375
80	367	369	376
70	367	369	376
60	367	369	377
50	367	370	378
40	368	370	380
35	368	371	382
30	369	371	385
25	369	372	390
20	370	374	397
15	371	377	415
CALCULATD VALUES	OF TC WITHOUT IMAGE REJECTION	FILTER(G ₁ /G _s =1.0 FO	R ALL FREQUENCIES)
CALCULATD VALUES	OF TC WITHOUT IMAGE REJECTION TC(DSB)	FILTER(G ₁ /G _s =1.0 FO TC(DSB)	R ALL FREQUENCIES) TC(DSB)
CALCULATD VALUES CLEVATION 90	OF TC WITHOUT IMAGE REJECTION TC(DSB) 735	FILTER(G _i /G _s =1.0 FO TC(DSB) 751	R ALL FREQUENCIES) TC(DSB) 850
CALCULATD VALUES CLEVATION 90 ©0	OF TC WITHOUT IMAGE REJECTION TC(DSB) 735 735	FILTER(G ₁ /G _s =1.0 FO TC(DSB) 751 752	R ALL FREQUENCIES) TC(DSB) 850 852
CALCULATD VALUES CLEVATION 90 ©0 70	OF TC WITHOUT IMAGE REJECTION TC(DSB) 735 735 735	FILTER(G ₁ /G _s =1.0 FO TC(DSB) 751 752 753	R ALL FREQUENCIES) TC(DSB) 850 852 859
CALCULATD VALUES CLEVATION 90 ©0 70 60	OF TC WITHOUT IMAGE REJECTION TC(DSB) 735 735 735 735 735	FILTER(G ₁ /G _s =1.0 FO TC(DSB) 751 752 753 755	R ALL FREQUENCIES) TC(DSB) 850 852 859 872
CALCULATD VALUES CLEVATION 90 00 70 60 50	OF TC WITHOUT IMAGE REJECTION TC(DSB) 735 735 735 735 735 735 736	FILTER(G ₁ /G _s =1.0 FO TC(DSB) 751 752 753 755 758	R ALL FREQUENCIES) TC(DSB) 850 852 859 872 893
CALCULATD VALUES CLEVATION 90 ©0 70 60 50 40	OF TC WITHOUT IMAGE REJECTION TC(DSB) 735 735 735 735 735 736 736 736	FILTER(G ₁ /G _s =1.0 FO TC(DSB) 751 752 753 755 758 764	R ALL FREQUENCIES) TC(DSB) 850 852 859 872 893 932
CALCULATD VALUES CLEVATION 90 80 70 60 50 40 35	OF TC WITHOUT IMAGE REJECTION TC(DSB) 735 735 735 735 735 736 736 737	FILTER(G ₁ /G _s =1.0 FO TC(DSB) 751 752 753 755 758 764 764 767	R ALL FREQUENCIES) TC(DSB) 850 852 859 872 893 932 963
CALCULATD VALUES CLEVATION 90 00 70 60 50 40 35 30	OF TC WITHOUT IMAGE REJECTION TC(DSB) 735 735 735 735 735 736 736 736 737 737	FILTER(G ₁ /G _s =1.0 FO TC(DSB) 751 752 753 755 758 764 764 767 773	R ALL FREQUENCIES) TC(DSB) 850 852 859 872 893 932 963 1007
CALCULATD VALUES CALCULATD VALUES CLEVATION 90 00 70 60 50 40 35 30 25	OF TC WITHOUT IMAGE REJECTION TC(DSB) 735 735 735 735 735 736 736 736 737 737 738	FILTER(G ₁ /G _s =1.0 FO TC(DSB) 751 752 753 755 758 764 767 773 780	R ALL FREQUENCIES) TC(DSB) 850 852 859 872 893 932 963 1007 1076
CALCULATD VALUES CALCULATD VALUES CLEVATION 90 00 70 60 50 40 35 30 25 20	OF TC WITHOUT IMAGE REJECTION TC(DSB) 735 735 735 735 736 736 736 737 737 737 738 740	FILTER(G ₁ /G _s =1.0 FO TC(DSB) 751 752 753 755 758 764 764 767 773 780 793	R ALL FREQUENCIES) TC(DSB) 850 852 859 872 893 932 963 1007 1076 1194
CALCULATD VALUES 2LEVATION 90 00 70 60 50 40 35 30 25 20 15	OF TC WITHOUT IMAGE REJECTION TC(DSB) 735 735 735 735 736 736 736 737 737 737 738 740 743	FILTER(G ₁ /G _s =1.0 FO TC(DSB) 751 752 753 755 758 764 767 773 780 793 816	R ALL FREQUENCIES) TC(DSB) 850 852 859 872 893 932 963 1007 1076 1194 1442
CALCULATD VALUES ELEVATION 90 00 70 60 50 40 35 30 25 20 15	OF TC WITHOUT IMAGE REJECTION TC(DSB) 735 735 735 736 736 736 736 737 737 737 738 740 743 VALUES USED FOR ABOVE CAL	FILTER(G ₁ /G _s =1.0 FO TC(DSB) 751 752 753 755 758 764 764 767 773 780 793 816 CULATIONS	R ALL FREQUENCIES) TC(DSB) 850 852 859 872 893 932 963 1007 1076 1194 1442
CALCULATD VALUES ELEVATION 90 00 70 60 50 40 35 30 25 20 15 T _{bg} = 2.7K	OF TC WITHOUT IMAGE REJECTION TC(DSB) 735 735 735 735 736 736 736 737 737 738 740 743 VALUES USED FOR ABOVE CAL T _m = 280K	FILTER(G ₁ /G _s =1.0 FO TC(DSB) 751 752 753 755 758 764 764 767 773 780 793 816 CULATIONS ⁿ source = 0.6	R ALL FREQUENCIES) TC(DSB) 850 852 859 872 893 932 963 1007 1076 1194 1442
CALCULATD VALUES ELEVATION 90 00 70 60 50 40 35 30 25 20 15 $T_{bg} = 2.7K$ $T_{sbr} = 280K$	OF TC WITHOUT IMAGE REJECTION TC(DSB) 735 735 735 735 736 736 737 737 738 740 743 VALUES USED FOR ABOVE CAL $T_m = 280K$ $\eta_{sky} = 0.87$	FILTER($G_i/G_s = 1.0$ FO TC(DSB) 751 752 753 755 758 764 764 767 773 780 793 816 CULATIONS ⁿ source = 0.6 T amb = 290K	R ALL FREQUENCIES) TC(DSB) 850 852 859 872 893 932 963 1007 1076 1194 1442

TC VALUES FOR CO SPECTRAL LINE CALIBRATION -- TABLE II USING CASSEGRAIN RECEIVER WITH QUASI-OPTICS BOX

Hollis, J.M., and Rhodes, P.J. 1976, NRAO Documatation Memo #1: Spectral Line Calibrations. Ulich, B.L., and Haas, R.W. 1976, <u>Ap. J. (Suppl.)</u>, <u>30</u>, 247-258. Wannier, P.G., Arnaud, J.A., Pelow, F.A., and Saleh, A.A.M. 1976, Rev. Sci. Instr., 47, 56-58.

Ulich, B.L., March 3, 1977, NRAO Memo: Accuracy of Spectral Line Intensity Calibration With Cassegrain Receiver.

Ulich, B.L., September 18, 1979, NRAO Memo: Calibration with Quasi-Optics Box Installed