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For IRAM use

Registration N°:

Date:

PROPOSAL FOR 30M TELESCOPE

Deadline: 18 Mar 2010 Period: 01 Jun 2010 — 30 Nov 2010

TITLE

Searching for Molecular Gas in IRAS 09104+4109 and RBS 797

Type: *Solar system:* continuum○ lines○ other○ *Extragalactic:* continuum○ CO lines● other○
Galactic: continuum○ lines○ circumstel. env.○ young stel. obj.○ cloud struct.○ chem.○ other○

ABSTRACT
A maximum of nine lines is reserved for the abstract.

Is this a resubmission of a previous proposal ? no● yes○ – proposal number(s): ....
Is this a continuation of (a) previous proposal(s) ? no● yes○ – proposal number(s): ....

Hours requested for this period

Total 14 EMIR 14 HERA MAMBO

LST range(s) and number of intervals
from: to: intervals:
from: to: intervals:

Special requirements: Large Program ○ pooled obs ○ service obs ○ remote obs ● polarimeter ○

Scheduling constraints: None

Receivers: EMIR ● HERA ○ MAMBO ○ Other ○

List of Objects (give most common names)

Epoch: J2000.0

Source	RA	DEC	V_{LSR} or z
IRAS09104	09:13:45.5	+40:56:28	0.4418

(for additional sources which do not fit here use the \extendedsourcelist macro)

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Expected observer(s) Cavagnolo

join to this form: scientific aims ≤ 2 typed pages (≤ 4 pages for Large Programs) and ≤ 2 pages Figs., Tabs., and Refs.

Technical Summary

Variables used:

T_A^*	expected line antenna temperature	T	requested telescope time per setup
Δv	required velocity resolution	pwv	precipitable water vapor: 1, 2, 4, 7, or 10 mm.

⋆ EMIR

Note that up to 4 IF signals can be recorded and up to 2 EMIR (always dual polarization) bands can be combined in one EMIR setup. For a summary of EMIR connectivity consult the IRAM Granada home page or the Call for Proposals

Transitions

setup	band	species	transition	frequency GHz	T_A^* mK	rms mK	Δv km s^{-1}	backend ^{a})
1	E0	CO	1-0	79.9	162.7	0.419	100.0	W
1	E1	CO	2-1	159.9	276.5	0.513	100.0	W
2	E2	CO	3-2	239.8	488.1	0.854	100.0	W

^{a}) V: VESPA, W: WILMA, 4: 4 MHz filterbank, 1: 1 MHZ filterbank

Observing parameters

map size in arcmin

setup No.	map size $\Delta x \times \Delta y$	mapping mode ^{a})	switching mode ^{b})	pwv mm	T hours	remark
1	$\times$	none	PSw	7	8	Dual-band observation with E1
1	$\times$	none	PSw	7	8	Dual-band observation with E0
2	$\times$	none	PSw	7	6	Single-band observation
Total EMIR time requested:					14	

^{a}) none, OTF (on–the–fly), R: Raster

^{b}) PSw: position switching, FSw: frequency switching, Wsw: wobbler sw.

Searching for Molecular Gas in IRAS 09104+4109 and RBS 797

Half of all galaxy clusters have an X-ray halo with a core cooling time $\ll H_0^{-1}$. These short cooling times should result in the formation of > 100 $M_\odot$ cooling flows [see Peterson & Fabian 2006, for a review]. Though much of the cooling flow material was expected to reside in < 3000 K gas and stars, observations indicate the expected prodigious mass deposition rates are actually much smaller, < 20 $M_\odot$ [Heckman et al. 1989, McNamara et al. 1990, O'Dea et al. 1994, Sanders et al. 2010]. A feedback loop involving active galactic nuclei (AGN) has emerged as the favored explanation for resolving this discrepency [Bîrzan et al. 2004, Bower et al. 2008, Croton et al. 2006, Dunn et al. 2005].

The feedback loop regulating the cooling of hot halos

Comparions between Perseus and IRAS09: similar Mbh (0.3e9) similar mech power (5d44) similar optical line emi (few d42) similar Mdot (500 Msol) BUT, Perseus has 5d7 Msol dust, I09 has 2d8

I09 has almost 10 times the dust content, but is undetected in CO. The big difference between I09 and Per, a QSO in I09.

so is the lack of mol gas a result of the QSO?

need a tight upper limit, or CO detection, to determine this.

– why care about CO in cool cores? much of CF material reside in 10-100 K stuff (ie CO) typical upper limits of 10-10 CFs are trickles, but some gas is cooling (Sanders RGS) but how much goes into CO?

– why look at iras09 deeper? macc rate is 500 Msol/py, which is XX Msol in XX Gyrs in extrem sys, line width may be ¿600 km/s, need bandwidth and sensitivity of EMIR is this perseus at z=0.4? halpha lum of XX predicts mol mass of XX, IRAS09 is poor, but by how much? evans found ¡ 10-10, but is 10-11 of CO hiding in HVCs? is the QSO resonsible for expelling? heating? mol gas? high-z means we probe whole of galaxy lots and lots of hot dust... but no cold dust, and no CO origin and state of cold phase is mysterious: CF or mergers? better instrument enables us to push limits of CO mass

– why repeat obs? EMIR has wider bandwidth, search for HVC, better cal lower rms, better mass limits

– what will we find out with iras09? are kinematics of CO consistent with CF

– how will we accomplish these goals? EMIR E0 8 GHz bandwidth E1 and up have 4 GHz bandwidth sufficient to see broad lines

– what obs are we requesting? ???

IRAS 09104+4109 (hereafter, IRAS09).

For wmap cosmo, evan 98 values (assuming dvfwhm=250 km/s, KJy = 5.0, MH2/Lco = 4):

J32 (trms = 6.2 mK, dvres = 31 km/s): Lco = 2.1e10 K km/s pc2 M(H2) = 8.39e10 msol

J21 (tmrs = 4.6 mK, dvres = 38 km/s): Lco = 1.7e10 M(H2) = 6.89e10

see plot of M(H2) for new obs

to go order of mag deeper than evans, need 5.5 hrs at J32 and 7 hrs on J21

res @... 79.9, 30.8" 159.9, 15.4" 239.8, 10.3" 319.7, 7.7"

J10, 115.2 GHz, red 79.9, E090 J21, 230.5 GHz, red 159.9, E150 J32, 345.7 GHz, red 239.8, E230 J43, 461.0 GHz, red 319.7, E300

The dichroics are needed for dual-band observations with EMIR. **** on average, increases sys temp by 10-15 K **** can combine: E090 & E150 E090 & E230 E150 & E330

combos (1% = 4K): E0/E2: 79.9+239.8, 2.5% and 5% E0/E1: 79.9+159.9, 4% and 1.5% E1/E3: 159.9+319.7, 3.5% and 2.5%

So, E0/E1 is best for us (22K vs. 30K at E0/E2), and increases Tsys in band where it's inherently lower

References

Bîrzan et al. ApJ, 607:800-809, June 2004. Bower et al. MNRAS, 390:1399-1410, November 2008. Cavagnolo et al. ApJ, 683:L107-L110, August 2008. Croton et al. MNRAS, 365:11-28, January 2006. Dunn et al. MNRAS, 364:1343-1353, December 2005. Fabian et al. MNRAS, 366:417-428, February 2006. Forman et al. ApJ, 665:1057-1066, August 2007. Heckman et al. ApJ, 338:48-77, March 1989. McNamara et al. ApJ, 360:20-29, September 1990. McNamara & Nulsen. ARA&A, 45:117-175, September 2007. O'Dea et al. ApJ, 422:467-479, February 1994. Peterson & Fabian. Phys. Rep., 427:1-39, April 2006. Peterson et al. ApJ, 590:207-224, June 2003. Rafferty et al. ApJ, 687:899-918, November 2008. Sanders et al. MNRAS, 402:127-144, February 2010. Tamura et al. A&A, 365:L87-L92, January 2001. Voit et al. ApJ, 681:L5-L8, July 2008.

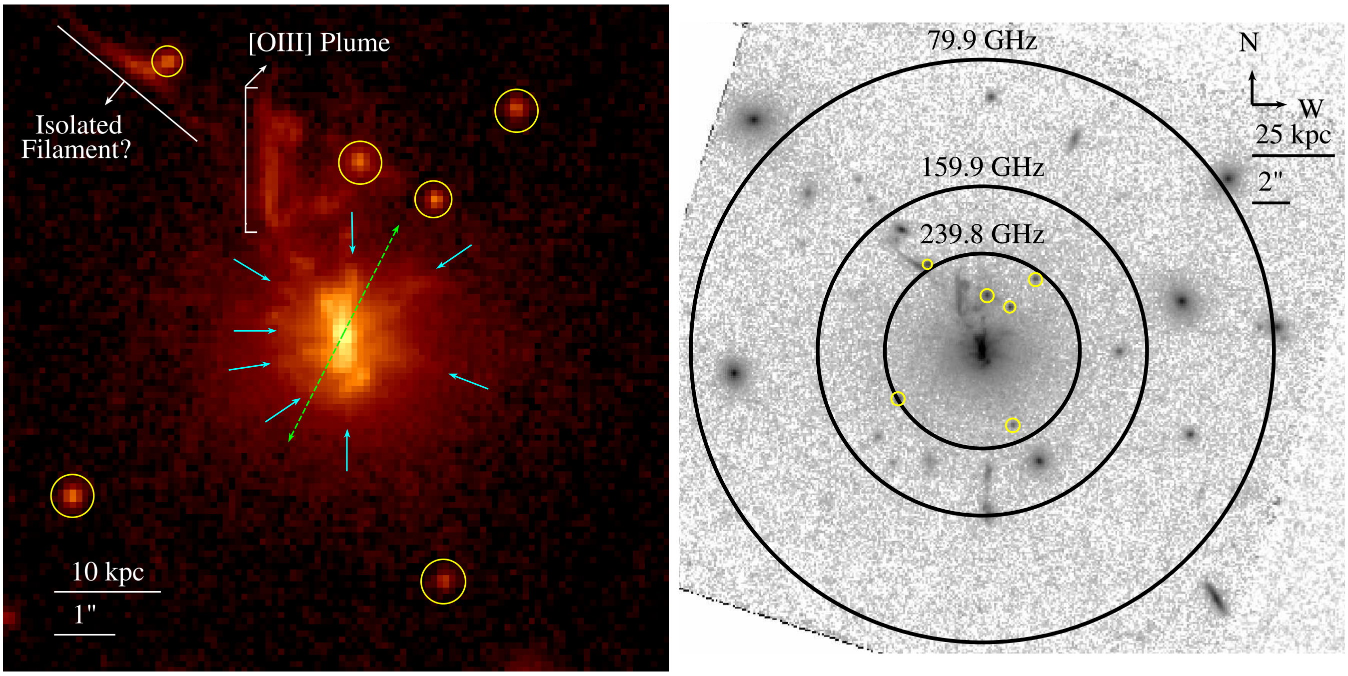

Figure 1: **Left:** HST *I*-band image of the IRAS09 BCG. Cyan arrows highlight "whiskers;" yellow circles enclose (stellar?) spheroids; green dashed line marks AGN axis. **Right**: HST *V*-band image of IRAS09 BCG. Black circles denote IRAM 30 m beam sizes at proposed observing frequencies; for reference, yellow circles from left panel are shown.

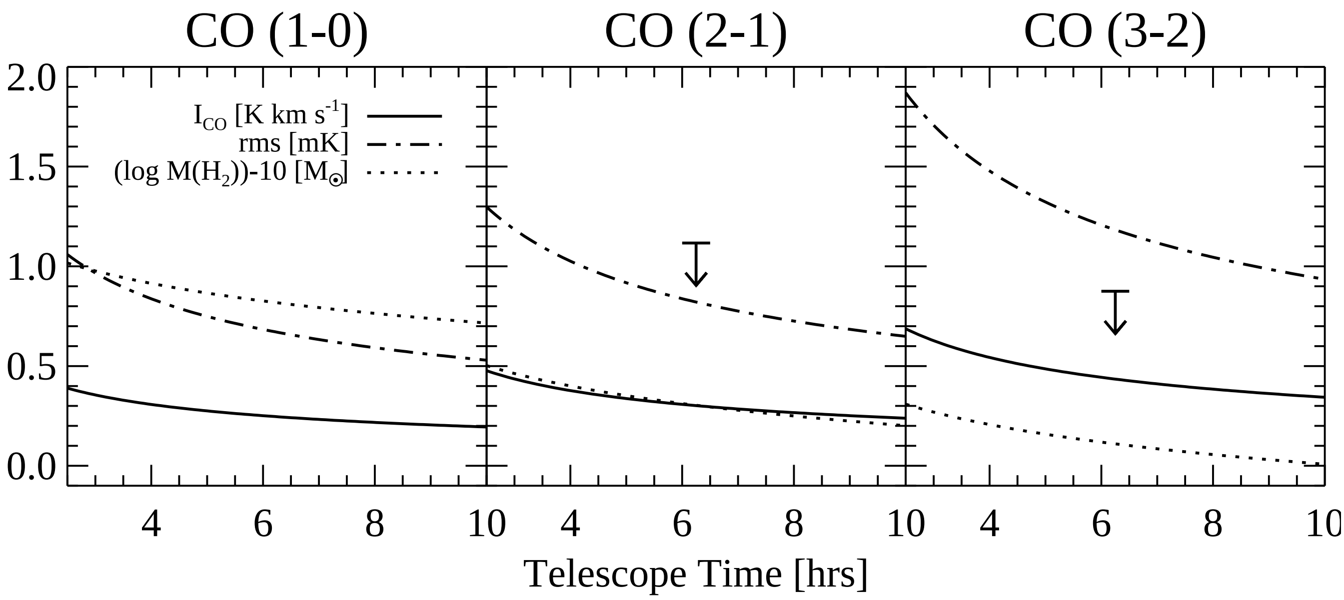

Figure 2: EMIR CO line intensity, rms noise, and H_2 mass as a function of position switched observing time. Solid lines are I_{CO} 3σ upper limits; dashed-dot lines are T_{rms} specific to elevation & ν_{obs}; dashed lines are M(H_2) 3σ upper limits; downward arrows are 3σ M(H_2) upper limits from Evans et al. 1998 (adjusted to our cosmology and I_{CO}:M(H_2) assumptions). The CO(1-0) and CO(2-1) calculations include the 16K and 6K T_{sys} increases, respectively, from use of the E0/E1 dichroic. All calculations assumed: 7 mm of precipitable water vapor, $\Delta v_{res} = 50$ km s^{-1}, $v_{FWHM}^{CO} = 300$ km s^{-1}, and backend efficiency of 0.87.