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**Identification of  $\gamma$ -ray sources from the 2FGL catalog using  
observations at lower frequencies.**

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Thesis

written to obtain the degree of

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by

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*Para Mariana y Zoe, mis faros en tiempo de tormenta.*



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Also, we made use of the database CATS (Verkhodanov et al. 2005) of the Special Astrophysical Observatory and of the VizieR catalogue access tool, CDS, Strasbourg, France.



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## Resumen

En 2011 se publicó el segundo catálogo de fuentes de rayos  $\gamma$  (2FGL) detectadas por el Telescopio de Gran Área (*Large Area Telescope*) de la misión Fermi (*Fermi Gamma-ray Space Telescope*). Este contiene 1873 fuentes de las cuales 575 están catalogadas como no identificadas con otros objetos previamente conocidos. En esta tesis se utilizaron los 447 registros no marcados como “confusos” para buscar contrapartes en frecuencias más bajas (radio, IR, óptico y rayos X).

Dado que la mayoría (83%) de las fuentes identificadas en el 2FGL son blazares y núcleos activos de galaxias nuestro trabajo fué motivado por Massaro et al. (2011) quienes mostraron que la emisión en infrarrojo de blazares ya conocidos ocupa una región distintiva en el diagrama color-color en dicha banda, denominada *Wise Gamma-ray Strip* (WGS). Siguiendo un método propuesto por Massaro et al. (2012a y 2012b) utilizamos el catálogo de fuentes en toda la esfera celeste del *Wide Infrared Survey Explorer* (WISE) para buscar una contraparte en IR dentro de la elipse de error de las fuentes 2FGL no identificadas que pudiera clasificarse como candidato a blazar. Se encontraron 378 fuentes IR en 196 de los 447 campos 2FGL.

En la segunda etapa se buscaron fuentes de radio coincidentes con estas 378 fuentes IR utilizando el *Catalogs supporting System* (CATS) y se encontró que 20 de ellas pueden asociarse con radio fuentes en sólo 18 campos 2FGL.

En la tercera etapa se utilizó esta última lista de campos 2FGL para ubicar contrapartes a los 20 candidatos en IR en óptico y rayos X para lo cual se utilizó la base de datos Vizier. En algunos casos existen observaciones de espectros en el óptico lo cual permite clasificar la fuente con un AGN o blazar. En cuatro de las 20 fuentes IR no se hallaron contrapartes en rayos X.

Con la información obtenida en las diferentes frecuencias se calcularon los índices espectrales (en radio) y se graficaron las distribuciones espectrales de energía, las cuales permitieron corroborar que las 18 fuentes 2FGL corresponden a diferentes clases de AGNs.

De estos 18 campos 2FGL, 15 fueron asociados por otros autores con objetos ya conocidos durante 2013 y publicados. Los tres restantes no habían sido reportados al término de este trabajo.

## Abstract

In 2011 the second catalog of high-energy  $\gamma$ -ray sources was published, as detected by the *Large Area Telescope* (LAT) of the *Fermi Gamma-ray Space Telescope* mission. This catalog (2FGL) contains 1873 sources and 575 of them are classified as unidentified with previously known objects. In this thesis we used the 447 of these fields not flagged as “confused” to search for counterparts at lower frequencies (radio, IR, optical and X-rays). Since most of the identified sources in the 2FGL (83%) are blazars and active galactic nuclei our work was motivated by Massaro et al. (2011) who showed that the IR emission of known blazars lies in a distinctive region in the color-color diagram, a region called *Wide Gamma-ray Strip* (WGS). Following a methodology proposed by Massaro et al. (2012a and 2012b) we used the all sky source catalog of the *Wide Infrared Survey Explorer* (WISE) to search for infrared counterparts inside the error ellipse of the 2FGL sources which could be classified as blazar candidates. We found 378 IR sources in 196 of the 447 2FGL fields. In the second stage we looked for radio sources coincident with these 378 IR sources using the *Catalogs supporting System* (CATS) and found 20 of them to be associated with a radio source in only 18 2FGL fields.

In the third stage we used this 18 2FGL fields to search for counterparts to the 20 IR candidates in optical and X-rays using the VizieR database. For some objects we found optical spectra which allow to classify them as blazar or AGN. We did not find an X-ray counterpart for 4 of the 20 IR sources.

With the information gathered from different frequencies we calculated the spectral indices (in radio) and prepared the Spectral Energy Distribution plots to corroborate that the 18 2FGL associations correspond to different classes of AGNs.

15 of the 18 2FGL fields have been associated to known objects by different authors and published during 2013. The other three were not reported in literature prior to the present work.