Data Mining In Modern Astronomy Sky Surveys: *Databases & Sloan Digital Sky Survey*

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Discussion of HW2:
Estimation of Hubble's Constant

RGui (64-bit)

File History Resize Windows

R Console

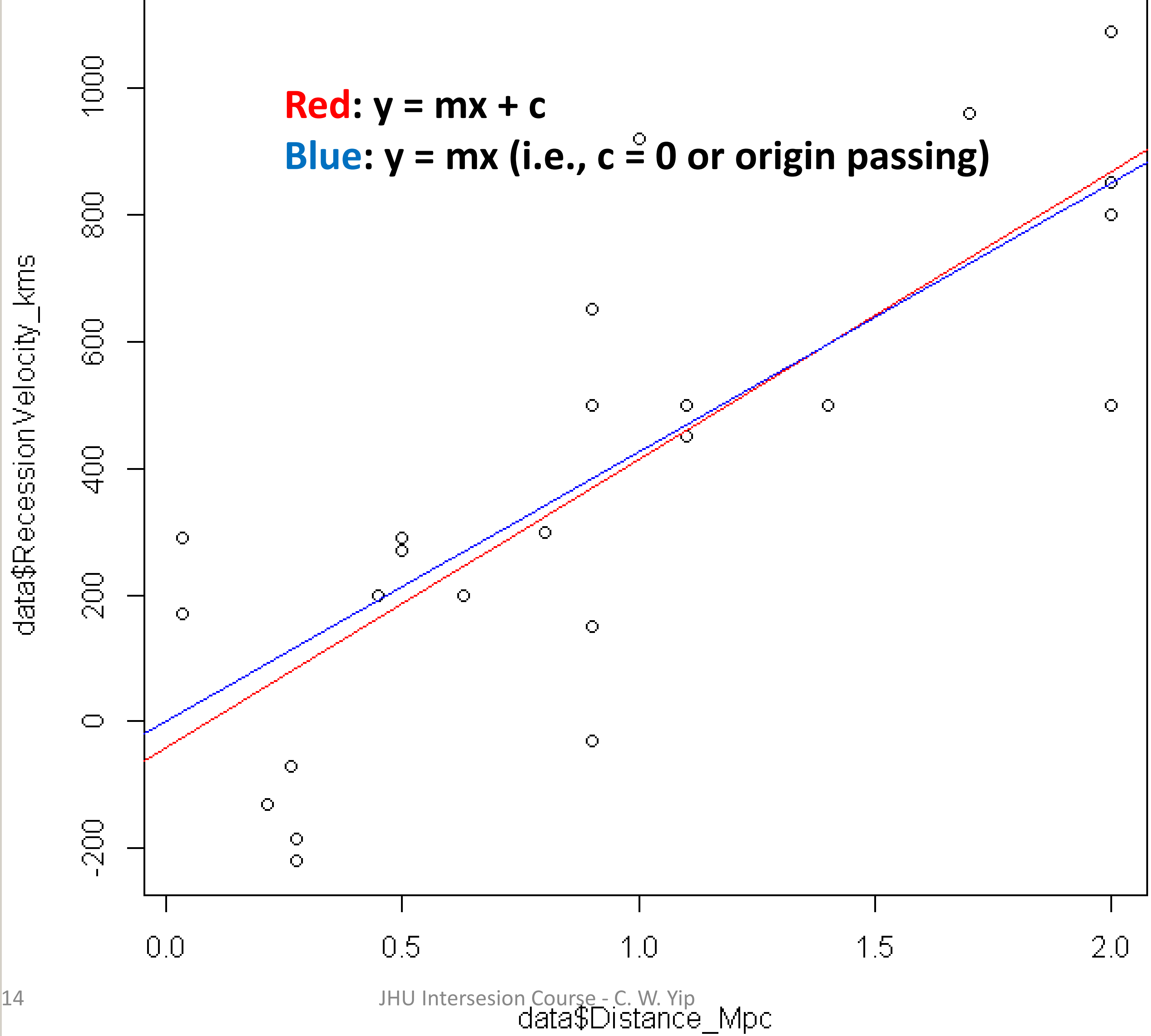
```
> # Read Hubble data file
> data <- read.csv('H:/public_html/teaching/hubbletable1.csv')
> # Show data
> data
   ObjectName Distance_Mpc RecessionVelocity_kms
1    SmallMag        0.032                   170
2    LargeMag        0.034                   290
3     NGC6822        0.214                  -130
4      NGC598        0.263                   -70
5      NGC221        0.275                  -185
6      NGC224        0.275                  -220
7     NGC5457        0.450                   200
8     NGC4736        0.500                   290
9     NGC5194        0.500                   270
10    NGC4449        0.630                   200
11    NGC4214        0.800                   300
12    NGC3031        0.900                   -30
13    NGC3627        0.900                   650
14    NGC4826        0.900                   150
15    NGC5236        0.900                   500
16    NGC1068        1.000                   920
17    NGC5055        1.100                   450
18    NGC7331        1.100                   500
19    NGC4258        1.400                   500
20    NGC4151        1.700                   960
21    NGC4382        2.000                   500
22    NGC4472        2.000                   850
23    NGC4486        2.000                   800
24    NGC4649        2.000                  1090
```

```
16    NGC1068        1.000              920
17    NGC5055        1.100              450
18    NGC7331        1.100              500
19    NGC4258        1.400              500
20    NGC4151        1.700              960
21    NGC4382        2.000              500
22    NGC4472        2.000              850
23    NGC4486        2.000              800
24    NGC4649        2.000             1090
> # Plot Recession Velocity vs. Distance of galaxies
> plot(data$Distance_Mpc, data$RecessionVelocity_kms)
> # Fit linear model
> fit1 <- lm(data$RecessionVelocity_kms ~ data$Distance_Mpc)
> # Add best-fit straight line
> abline(fit1, col = 'red')
> # Show best-fit parameters
> fit1

Call:
lm(formula = data$RecessionVelocity_kms ~ data$Distance_Mpc)

Coefficients:
      (Intercept)  data$Distance_Mpc
           -40.78             454.16

> # Fit origin-passing linear model
> fit2 <- lm(data$RecessionVelocity_kms ~ data$Distance_Mpc + 0)
> # Add best-fit straight line
> abline(fit2, col = 'blue')
> # Show best-fit parameters
> fit2
```


Red: y = mx + c
Blue: y = mx (i.e., c = 0 or origin passing)
data$RecessionVelocity_kms
data$Distance_Mpc
-200
0
200
400
600
800
1000
0.0
0.5
1.0
1.5
2.0

Discussion HW2

- The calculated values (454 km/s/Mpc) is a factor of a few larger than the WMAP value (71 km/s/Mpc).
- This discrepancy suggests that there could be systematic error in Hubble’s measurements of Recession Velocity or/and Distance. The error could be due to the measurement techniques and/or the local galaxy sample.
- Photon count = 100 implies SNR = $\sqrt{100} = 10$.
- By using the simplified Rose Criterion, the minimum number of photons for 100% feature detection is $5^2 = 25$.

Further Readings on Data Mining and Machine Learning

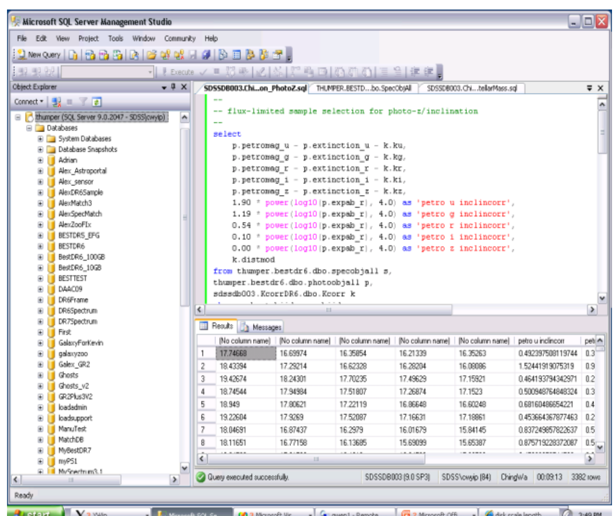
- Statistical Data Analysis (Cowan)
  - Practical reference/textbook
- A Modern Introduction to Probability and Statistics (Dekking, Kraaikamp, Lopuhaä, Meester)
  - Self-content textbook
  - Freely downloadable online
- All of Statistics (Wasserman)
  - Comprehensive; Advanced read
- Neural Networks for Pattern Recognition (Bishop)
  - Focus on concepts
  - Freely downloadable online

From Data to Information

- We don’t just want data.
- We want information from the data.

Information ← **Database** ← **Sensors**

Data Analysis
or
Data Mining



Topics

- Database
- Table
- Structured Query Language (SQL)
- Sloan Digital Sky Survey (SDSS) and Web Services
- Example SQL queries in Astronomy:
  - Create binned histograms of galaxies
  - Select targets for follow-up spectroscopy
  - Find extreme galaxies (i.e., outliers)

Basics of Database

- A database stores a collection of data.
- The data are arranged in database objects such as tables.
- Relational Database: a database which uses table(s).
  - The "relation" refers to the relation among different fields within one table.
  - The "relation" does not refer to the potential relation among multiple tables.

Basics of Tables

- Row is called Record.
- Column is called Field.
- Schema: logical container for database objects that user creates.
- Records are stored in the tables with some order:
  - The records are not necessarily sorted by a particular column.

Table contains Unique Records: Primary Key

- We want to be able to retrieve each and every record.
- Solution: Each record in a table is unique.
- This unique ID is called Primary Key.
- In the SDSS, some Primary Keys are:
  - ObjID (in table PhotoObjAll)
  - SpecObjID (in table SpecObjAll)

Primary Key

First Name	Last Name	Credit Card #
George	Daniels	184715170968
Amy	Lee	207609796702
Brandon	Willis	982767757110
Jennifer	Connolly	486830981903
Andrew	Folks	601571389801

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Primary Key

ID	First Name	Last Name	Credit Card #
1	George	Daniels	184715170968
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3	Brandon	Willis	982767757110
4	Jennifer	Connolly	486830981903
5	Andrew	Folks	601571389801

Foreign Key

- A Foreign Key is a field of a table (*child table*) that uniquely identifies a row in another table (*parent table*).
- A Foreign Key hence ties two tables together.
- In the "Customer and Purchase" tables, CreditCard # is the Foreign Key.

Un-Normalized Table

- In un-normalized table:
  - Records may grow very quickly.
  - Redundant records may present.
- Solution: Split data into multiple tables.
- In Astronomy: Data are fixed once the survey is completed. But tables are long, normalization improves performance.
- In Industry (banking/searching/facebook etc.): Data are growing fast, giving many records for a given user. Normalization is important.

Un-Normalized Table: Purchase

First Name	Last Name	Credit Card #	Date	Amount
George	Daniels	184715170968	01/05/2013	125.6
Amy	Lee	207609796702	01/07/2013	45.50
George	Daniels	184715170968	01/07/2013	72.35
Brandon	Willis	982767757110	01/09/2013	38.97
Jennifer	Connolly	486830981903	01/08/2013	49.83
George	Daniels	184715170968	01/10/2013	72.35
Andrew	Folks	601571389801	01/12/2013	92.30

- There are redundant data in this table.

Split Data into 2 Tables: Customer and Purchase

First Name	Last Name	Credit Card #
George	Daniels	184715170968
Amy	Lee	207609796702
Brandon	Willis	982767757110
Jennifer	Connolly	486830981903
Andrew	Folks	601571389801

- No redundant data.
- Two tables grow at different rate!

Credit Card #	Date	Amount
184715170968	01/05/2013	125.6
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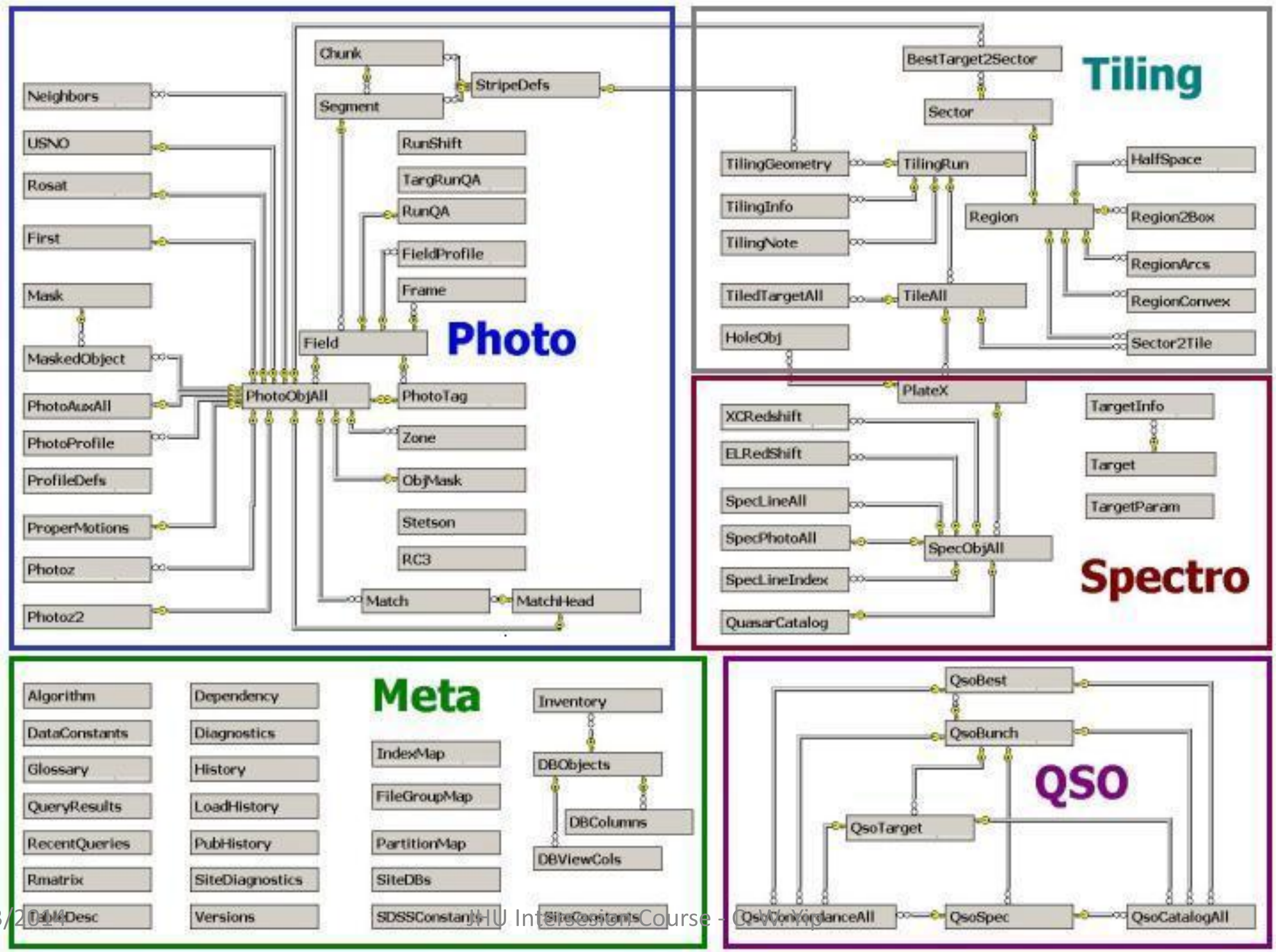
- Two tables grow at different rate!

A single spreadsheet is not the best approach for storing big data!

Credit Card #	Date	Amount
184715170968	01/05/2013	125.6
207609796702	01/07/2013	45.50
184715170968	01/07/2013	72.35
982767757110	01/09/2013	38.97
486830981903	01/08/2013	49.83
184715170968	01/10/2013	72.35
601571389801	01/12/2013	92.30

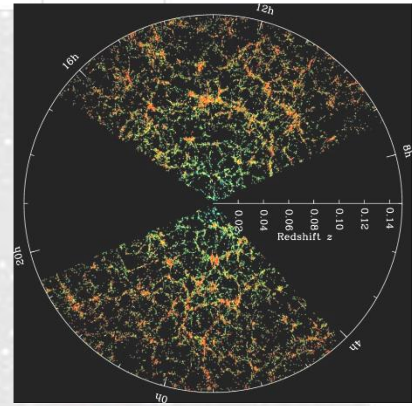
85 Tables in SDSS DR7



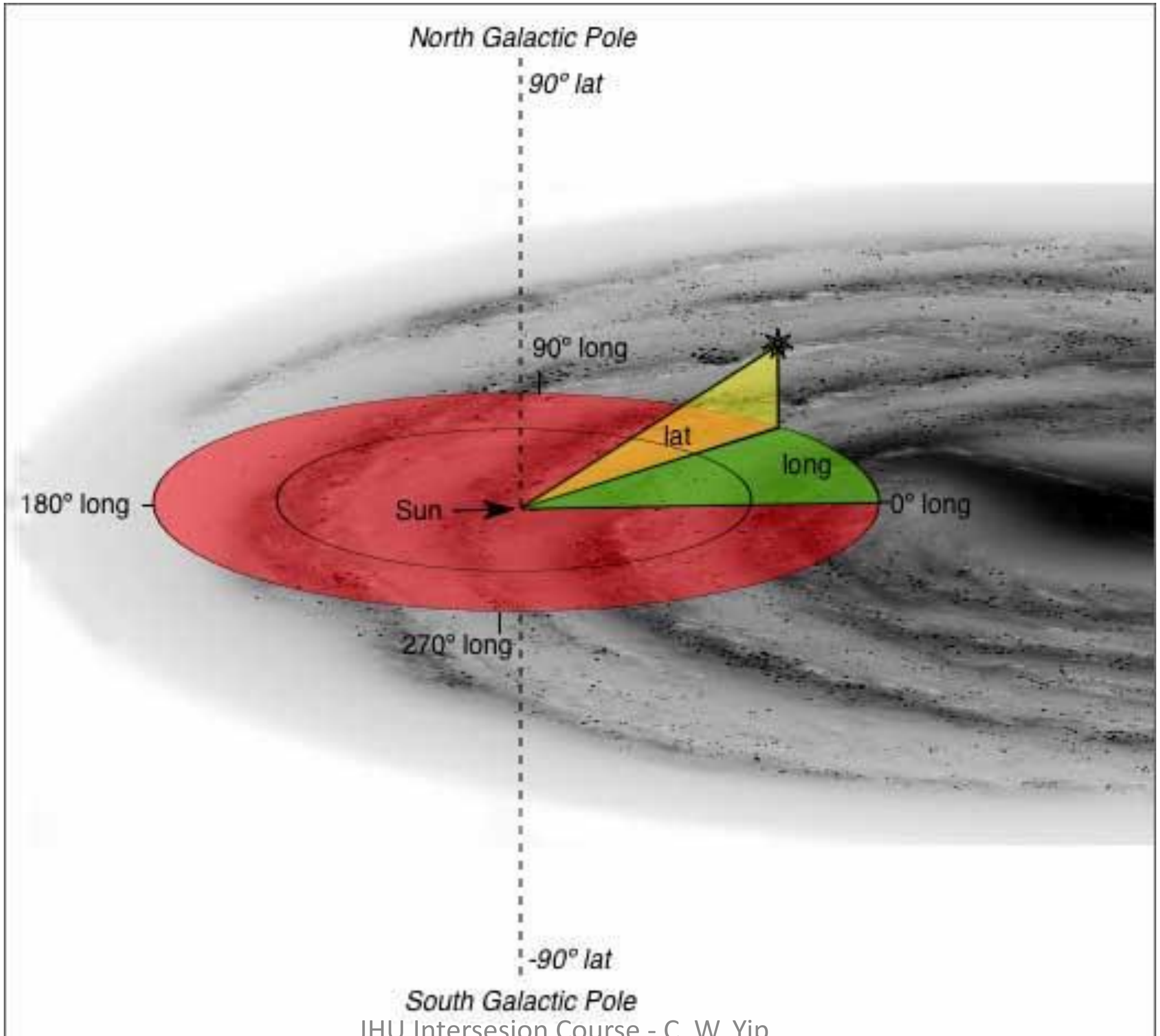
Sloan Digital Sky Survey (2000-)

- Photometric + Spectroscopic Surveys
    - 11,000 square degree footprint (DR7)
    - 5.9×10^8 u, g, r, i, z photometry
    - 1.6×10^6 fiber spectra
- Phases
    - SDSS I (2000-05)
    - SDSS II (2005-08)
    - SDSS III (2008-14)
    - SDSS 4 (Current)
- Data are public
- Web interfaces for data download & exploration
    - SkyServer, DAS, etc.

(Galaxy Distribution)

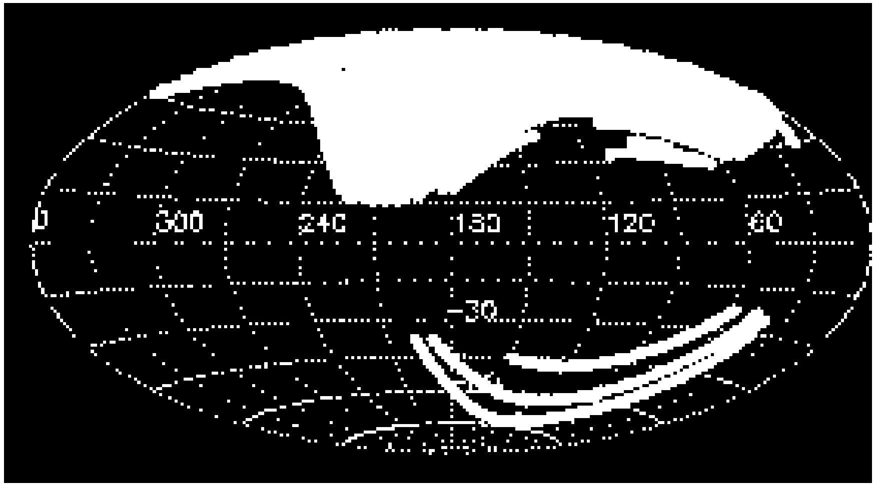


SDSS Footprints (DR7): in Galactic Coordinate Systems

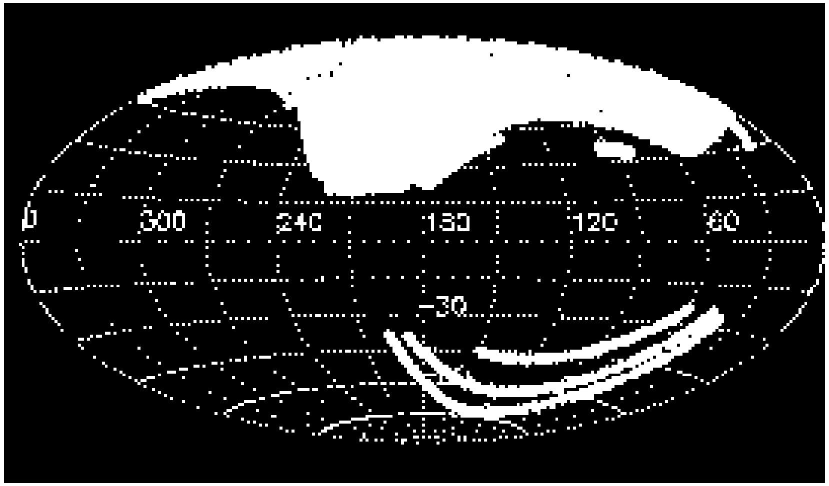


SDSS Footprints (DR7):
in Galactic Coordinate Systems

Photometry



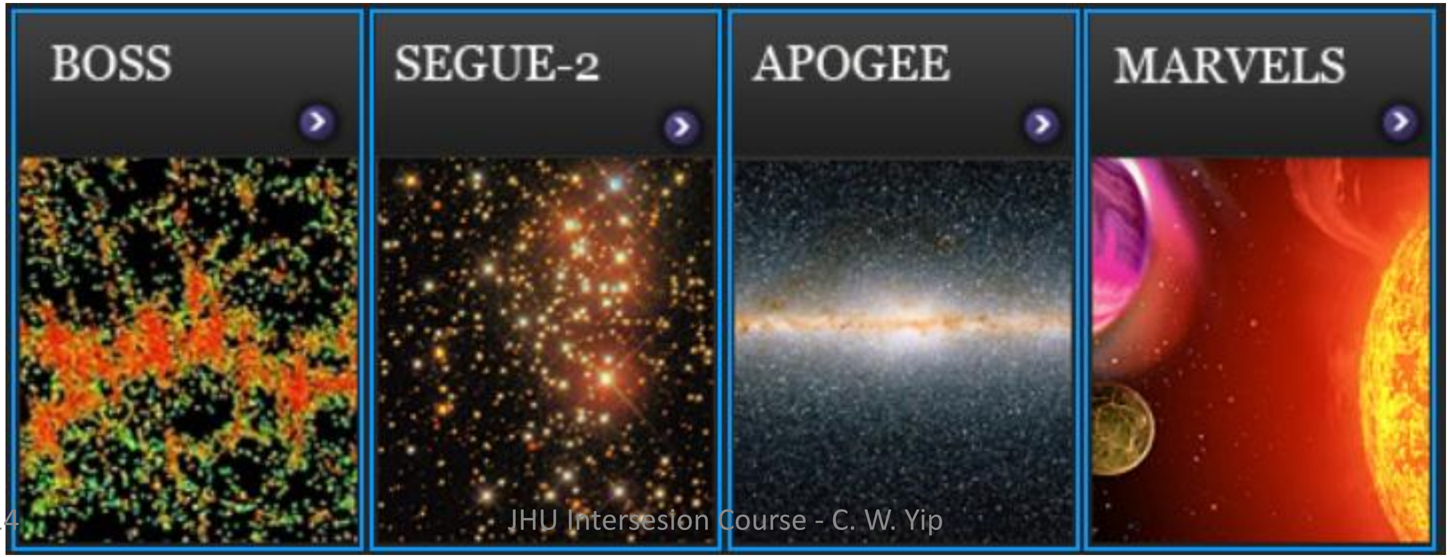
Spectroscopy



Southern Stripes: Offer repeated scans (time-domain information) of the sky!

SDSS III

- BOSS
  - Map distribution of galaxies out to redshift of 0.7, which has imprints information about the cosmic microwave background.
- SEGUE-2
  - Map Milky Way structure by measuring optical spectra of 119,000 stars.
- APOGEE
  - Map dust-obscured disk and bulge of Milky Way by measuring Infrared spectra of stars.
- MARVELS
  - Search for exoplanets by monitoring radial velocities of 11,000 stars.



Statistics of SDSS Databases (Data Release 7, or DR7)

- Number of tables: 85
- Data Volume:
  - Images (16 TB)
  - Tables (18 TB)
  - Data Products (27 TB)
- PhotoObjAll
  - Number of rows: 585,634,220
  - Number of columns: 454
- SpecObjAll
  - Number of rows: 1,640,960
  - Number of columns: 63

Web Services for SDSS Data

- SkyServer and CasJobs
  - Nolan Li, Alex Szalay, Ani Thakar, Tamas Budavari et al.
- Spectrum Services
  - Dobos et al.
- Open SkyQuery
  - Dobos et al. 2014 in prep.

SkyServer.org - Team

The team behind the skyserver are multitalented and have various backgounds. You have seen the names - here are the faces.

Tamas Budavari

George Fekete

Sam Carliles

Nolan Li

Maria Nieto-Santisteban

Tanu Malik

William O'Mullane

Adrian Pope

Jordan Raddick

Alex Szalay

Ani Thakar

Jan van den Berg

SDSS SkyServer DR7 - Windows Internet Explorer
http://cas.sdss.org/dr7/en/
Inbox (25,791) - dear...
SQL Tutorial for begi...
SDSS SkyServer DR7
sdss dr7 skyserver
Search
Share
More
ching wa yip
Sloan Digital Sky Survey / SkyServer
SDSS
Home
Tools
Schema
Projects
Astronomy
SDSS
Contact Us
Download
Site Search
Help
Welcome to the DR7 site!!!
This website presents data from the Sloan Digital Sky Survey, a project to make a map of a large part of the universe. We would like to show you the beauty of the universe, and share with you our excitement as we build the largest map in the history of the world.
News
The site hosts data from Data Release 7 (DR7). What's new in DR7, what's new on this site, and known problems.
More...
For Astronomers
A separate branch of this website for professional astronomers (English)
More...
SDSS is supported by
NSF
NASA
MEXT
Powered by
Microsoft
SkyServer Tools
Famous places
Get images
Visual Tools
Explore
Search
Object Cross-ID
CasJobs
Science Projects
Basic
Advanced
Challenges
For Kids
Games and Contests
Teachers
Links to other projects
Info Links
About Astronomy
About the SDSS
About the SkyServer
SDSS Data Release 7
SDSS Project Website
Open SkyQuery
Images of RC3 Galaxies
Help
Getting Started
FAQ
How To
Glossary
Schema Browser
Sample SQL Queries
Details of SDSS Data
Site Traffic
Privacy Policy
Contact Us

SkyServer Schema Browser - Windows Internet Explorer

http://cas.sdss.org/dr7/en/help/browser/browser.asp

Sloan Digital Sky Survey / SkyServer

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Schema Browser

Glossary
Algorithms

Search for [ ] Go

- Tables
- Views
- Functions
- Procedures
- Constants
- Indices

TABLE PhotoObjAll

Contains a record describing the attributes of each photometric object

The table has views:

- **PhotoObj**: all primary and secondary objects; essentially this is the view you should use unless you want a specific type of object.
- **PhotoPrimary**: all photo objects that are primary (the best version of the object).
  - **Star**: Primary objects that are classified as stars.
  - **Galaxy**: Primary objects that are classified as galaxies.
  - **Sky**:Primary objects which are sky samples.
  - **Unknown**:Primary objects which are noOne of the above
- **PhotoSecondary**: all photo objects that are secondary (secondary detections)
- **PhotoFamily**: all photo objects which are neither primary nor secondary (blended)

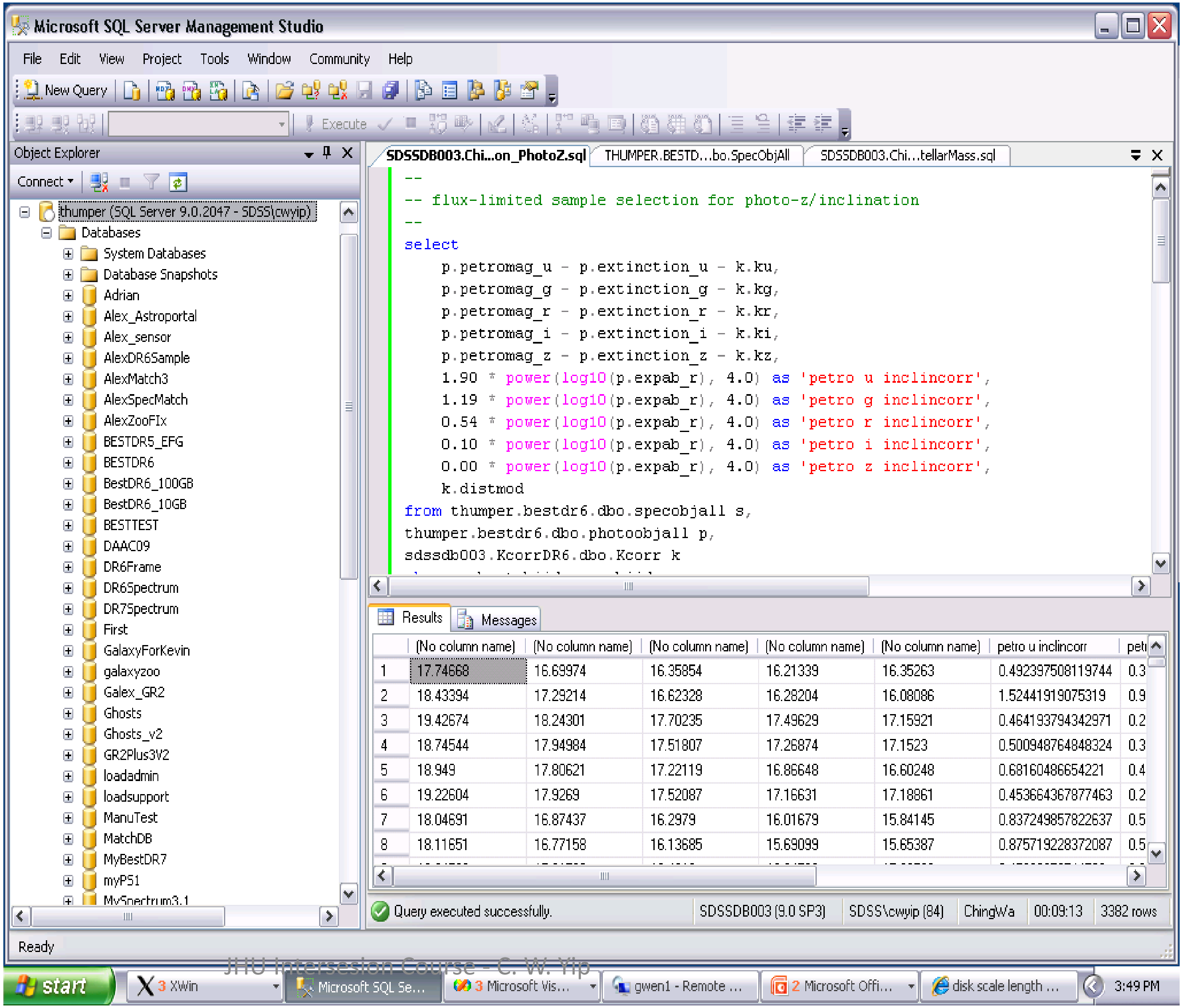
The table has indices that cover the popular columns.

name	type	length	unit	ucd	description
objID	bigint	8		ID_MAIN	Unique SDSS identifier composed from [skyVersion,rerun,run,camcol,field,obj].
skyVersion	tinyint	1		CODE_MISC	0 = OPDB target, 1 = OPDB best
run	smallint	2		OBS_RUN	Run number
rerun	smallint	2		CODE_MISC	Rerun number
camcol	tinyint	1		INST_ID	Camera column
field	smallint	2		ID_FIELD	Field number
obj	smallint	2		ID_NUMBER	The object id within a field. Usually changes between reruns of the same field.
mode	tinyint	1		CLASS_OBJECT	1: primary, 2: secondary, 3: family object, 4: outside chunk boundary.
nChild	smallint	2		NUMBER	Number of children if this is a composite object that has been deblended. BRIGHT (in a flags sense) objects also have nchild == 1, the non-BRIGHT sibling.
type	smallint	2		CLASS_OBJECT	Morphological type classification of the object.
clean	int	4		CODE_MISC	Clean photometry flag for point sources (1=clean, 0=unclean).
probPSF	real	4		STAT_PROBABILITY	Probability that the object is a star. Currently 0 if type == 3 (galaxy), 1 if type == 6 (star).
insideMask	tinyint	1		CODE_MISC	Flag to indicate whether object is inside a mask and why
flags	bigint	8		CODE_MISC	Photo Object Attribute Flags

Using Microsoft SQL Server in Astronomy (Szalay & Gray)

Other choices:

- Oracle
- MySQL



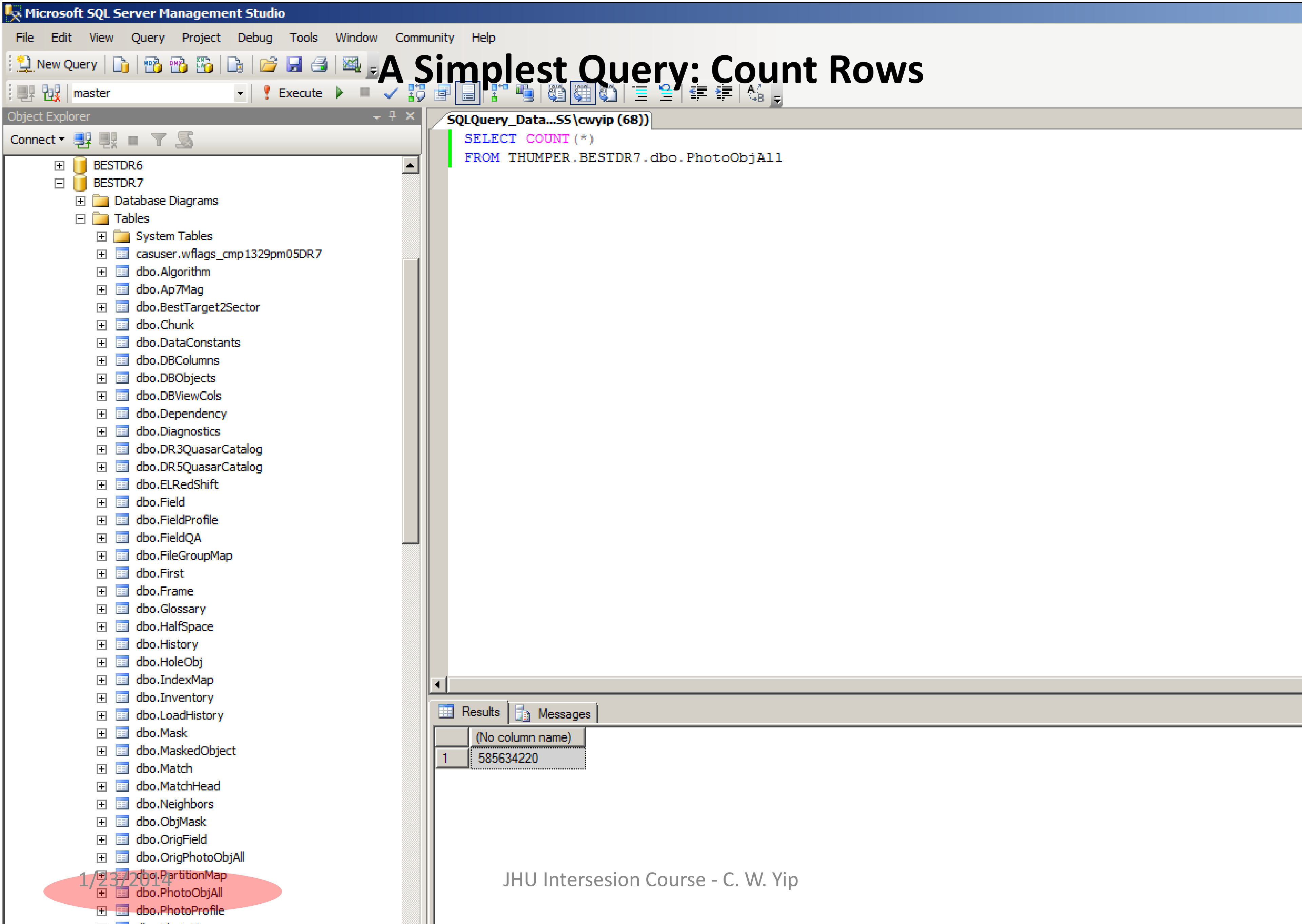
Practical SQL

- We execute queries to manage and retrieve the data.
- The queries are written in Structured Query Language (SQL), which has the form:

SELECT *column(s)*
FROM *table(s)*
WHERE *predicate(s) are true*

- SQL queries can get long and complicated.

A Simplest Query: Count Rows



Show Top Records

Microsoft SQL Server Management Studio

File Edit View Query Project Debug Tools Window Community Help

New Query | master | Execute

Object Explorer

Connect ▾

- dbo.PhotoObjAll
  - Columns
    - objID (PK, bigint, not null)
    - skyVersion (tinyint, not null)
    - run (smallint, not null)
    - rerun (smallint, not null)
    - camcol (tinyint, not null)
    - field (smallint, not null)
    - obj (smallint, not null)
    - mode (tinyint, not null)
    - nChild (smallint, not null)
    - type (smallint, not null)
    - clean (int, not null)
    - probPSF (real, not null)
    - insideMask (tinyint, not null)
    - flags (bigint, not null)
    - rowc (real, not null)
    - rowcErr (real, not null)
    - colc (real, not null)
    - colcErr (real, not null)
    - rowv (real, not null)
    - rowvErr (real, not null)
    - colv (real, not null)
    - colvErr (real, not null)
    - rowc_u (real, not null)
    - rowc_g (real, not null)
    - rowc_r (real, not null)
    - rowc_i (real, not null)
    - rowc_z (real, not null)
    - rowcErr_u (real, not null)
    - rowcErr_g (real, not null)
    - rowcErr_r (real, not null)
    - rowcErr_i (real, not null)
    - rowcErr_z (real, not null)
    - colc_u (real, not null)
    - colc_g (real, not null)
    - colc_r (real, not null)
    - colc_i (real, not null)
    - colc_z (real, not null)
    - colcErr_u (real, not null)
    - colcErr_g (real, not null)
    - colcErr_r (real, not null)
    - colcErr_i (real, not null)
    - colcErr_z (real, not null)
    - sky_u (real, not null)
    - sky_g (real, not null)
    - sky_r (real, not null)
    - sky_i (real, not null)
    - sky_z (real, not null)
    - skyErr_u (real, not null)
    - skyErr_g (real, not null)
    - skyErr_r (real, not null)

SQLQuery_Data...\cwyip (68))*

```sql
SELECT TOP 10 *
FROM THUMPER.BESTDR7.dbo.PhotoObjAll
```

Results | Messages

	objID	skyVersion	run	rerun	camcol	field	obj	mode	nChild	type	clean	probPSF	insideMask	flags	rowc	rowcErr	colc
1	587722951693303809	1	745	40	1	518	1	3	1	6	0	1	0	34628571982	67.31985	0.008972449	49.60184
2	587722951693303810	1	745	40	1	518	2	2	0	6	0	1	0	310109256160076	67.25411	0.002876111	49.69498
3	587722951693303811	1	745	40	1	518	3	3	0	0	0	-9999	0	281619127075148	-6.699471	0.1010417	1098.149
4	587722951693303812	1	745	40	1	518	4	3	1	6	0	1	0	268435970	37.28694	0.01529532	1793.392
5	587722951693303813	1	745	40	1	518	5	3	0	6	0	1	0	268435968	37.10624	0.007697065	1793.54
6	587722951693303814	1	745	40	1	518	6	3	1	6	0	1	0	17592454611530	43.78992	0.01509366	1875.807
7	587722951693303815	1	745	40	1	518	7	3	0	6	0	1	0	17599434461772	43.60673	0.005338188	1875.988
8	587722951693303816	1	745	40	1	518	8	3	1	6	0	1	0	448635372704330	60.17922	0.007902309	496.6865
9	587722951693303817	1	745	40	1	518	9	3	11	6	0	1	0	1046988272308748	48.23613	0.1025441	567.655
10	587722951693303818	1	745	40	1	518	10	3	0	6	0	1	0	483787533062164	48.23613	0.1025441	567.655

Predicates (or Conditions)

- These inequalities can be used in predicates:

=

>

<

>=

<=

<> ("not equal")

```
SELECT COUNT(*)
FROM PhotoObjAll
WHERE PetroMag_r < 17.7
```

It means:
Count the number of rows in PhotoObjAll where the r-band measured magnitude is brighter than 17.7.

ORDER BY

- We use “ORDER BY” to sort the output into increasing order.

```
SELECT Top 10 ObjID, petroMag_r
FROM PhotoObjAll
WHERE petroMag_r < 17.7
ORDER BY ObjID
```

Results | Messages

	ObjID	petroMag_r
1	587722951693303809	15.7723
2	587722951693303810	15.72362
3	587722951693303811	-9999
4	587722951693303812	13.67365
5	587722951693303814	12.77901
6	587722951693303815	17.15969
7	587722951693303816	12.26275
8	587722951693303817	12.51592
9	587722951693303818	12.51581
10	587722951693303819	15.29029

Nullable?

- A field that is allowed to have no values is called “nullable”.
- Determined when creating the database.
- In SDSS, many unavailable fields have values “-9999”.

```
SELECT Top 10 ObjID, petroMag_r
FROM PhotoObjAll
WHERE petroMag_r < 17.7
AND petroMag_r <> -9999
ORDER BY ObjID
```

Results | Messages

	ObjID	petroMag_r
1	587722951693303809	15.7723
2	587722951693303810	15.72362
3	587722951693303812	13.67365
4	587722951693303814	12.77901
5	587722951693303815	17.15969
6	587722951693303816	12.26275
7	587722951693303817	12.51592
8	587722951693303818	12.51581
9	587722951693303819	15.29029
10	587722951693303829	16.165

Aggregate ("Bag") Functions:
Group a field from multiple rows together

- Commonly used aggregate functions include:

  COUNT()

  MIN()

  MAX()

  AVG()

  STDEV()

- For big tables, aggregate functions may take a long time to finish.

```
SELECT COUNT(*) as 'Count', MIN(z) as 'Min z', MAX(z) as 'Max z', AVG(z) as 'Avg z', STDEV(z) as 'SD z'
FROM SpecObjAll
WHERE specClass = 2
```

Results | Messages

	Count	Min z	Max z	Avg z	SD z
1	929555	-0.00102696	5.535	0.148379266605181	0.129811220106478

GROUP BY

- We use “GROUP BY” to group output by column(s).
- Often used together with aggregate functions.

```
SELECT specClass, COUNT(*) as 'Count', MIN(z) as 'Min z', MAX(z) as 'Max z', AVG(z) as 'Avg z',
        STDEV(z) as 'SD z'
FROM SpecObjAll
WHERE z <> -9999
GROUP BY specClass
```

Results | Messages

	specClass	Count	Min z	Max z	Avg z	SD z
1	0	28235	-0.0103452	6.0056	0.639171930381876	0.859499572096409
2	1	380214	-0.00608471	2.25871	-5.57450855498839E-05	0.00810945834990001
3	2	929555	-0.00102696	5.535	0.148379266605181	0.129811220106478
4	3	111693	0.00153095	6.00497	1.34311277729218	0.783828972313012
5	4	9670	1.31091	5.1854	2.96745617192435	0.542437385679024
6	6	84047	-0.00571032	2.21458	0.000109805128786711	0.0155157912061197

SpecClass Data values

name	value	description
UNKNOWN	0	Spectrum not classifiable (zConf < 0.25).
STAR	1	Spectrum of a star.
GALAXY	2	Spectrum of a galaxy.
QSO	3	Spectrum of a quasi-stellar object.
HIZ_QSO	4	Spectrum of a high-redshift quasar (z>2.3), whose redshift is confirmed by a Ly-alpha estimator (see "Spectroscopic Redshift and Type Determination" section in Algorithms).
SKY	5	Spectrum of blank sky.
STAR_LATE	6	Star dominated bt molecular bands M or later.
GAL_EM	7	Emission line galaxy (placeholder).

Results | Messages

	specClass	Count	Min z	Max z	Avg z	SD z
1	0	28235	-0.0103452	6.0056	0.639171930381876	0.859499572096409
2	1	380214	-0.00608471	2.25871	-5.57450855498839E-05	0.0081094583499001
3	2	929555	-0.00102696	5.535	0.148379266605181	0.129811220106478
4	3	111693	0.00153095	6.00497	1.34311277729218	0.783828972313012
5	4	9670	1.31091	5.1854	2.96745617192435	0.542437385679024
6	6	84047	-0.00571032	2.21458	0.000109805128786711	0.0155157912061197

SQL Example:
Create Binned Redshift Histogram of Galaxies

- Suppose we want to know the redshift distribution of galaxies from the SDSS spectroscopic data.

```
DECLARE @binsize FLOAT
SET @binsize = 0.1

SELECT FLOOR(z / @binsize) * @binsize as 'Redshift',
          COUNT(*)  as 'Number of Galaxies'
FROM THUMPER.BESTDR7.dbo.SpecObjAll
WHERE specClass = 2
AND z BETWEEN 0 and 1
GROUP BY FLOOR(z / @binsize) * @binsize
ORDER BY FLOOR(z / @binsize) * @binsize
```

Results | Messages

	Redshift	Number of Galaxies
1	0	380348
2	0.1	361738
3	0.2	76670
4	0.3	68830
5	0.4	34001
6	0.5	5710
7	0.6	1078
8	0.7	344
9	0.8	355
10	0.9	22

SQL Example:
Create Binned 2D (Redshift, Magnitude) Histogram of Galaxies

- We can select fields from multiple tables.
- We can also use the clause “JOIN” explicitly for this example.

```
DECLARE @binsize_z FLOAT
DECLARE @binsize_m FLOAT
SET @binsize_z = 0.1
SET @binsize_m = 0.2

SELECT FLOOR(s.z / @binsize_z) * @binsize_z as 'Redshift',
        FLOOR(petroMag_r / @binsize_m) * @binsize_m as ‘Magnitude’,
        COUNT(*) as 'Number of Galaxies'
FROM THUMPER.BESTDR7.dbo.SpecObjAll s, THUMPER.BESTDR7.dbo.PhotoObjAll p
WHERE specClass = 2
AND s.bestObjID = p.objID
AND s.z BETWEEN 0 and 0.2
AND p.petroMag_r BETWEEN 16.7 and 17.7
GROUP BY FLOOR(s.z / @binsize_z) * @binsize_z, FLOOR(petroMag_r / @binsize_m) * @binsize_m
ORDER BY FLOOR(s.z / @binsize_z) * @binsize_z, FLOOR(petroMag_r / @binsize_m) * @binsize_m
```

Results | Messages

	Redshift	Magnitude	Number of Galaxies
1	0	16	17638
2	0	16.2	21191
3	0	16.4	24836
4	0	16.6	28450
5	0	16.8	32314
6	0	17	1
7	0.1	16	2963
8	0.1	16.2	5436
9	0.1	16.4	9629
10	0.1	16.6	15175
11	0.1	16.8	24095

Data Analysis using Database

- Automated data analysis:

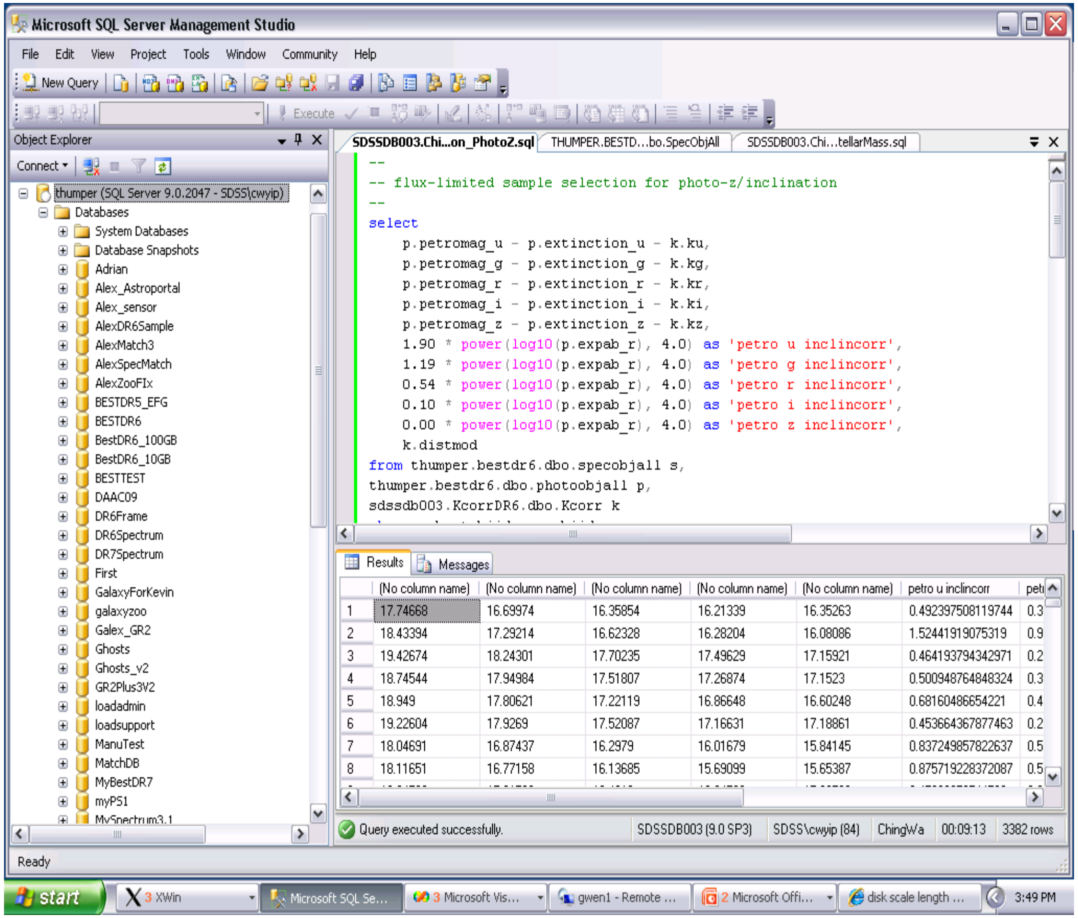
Select data from DB using C# routines with SQL scripts embedded

↓

Perform computations

↓

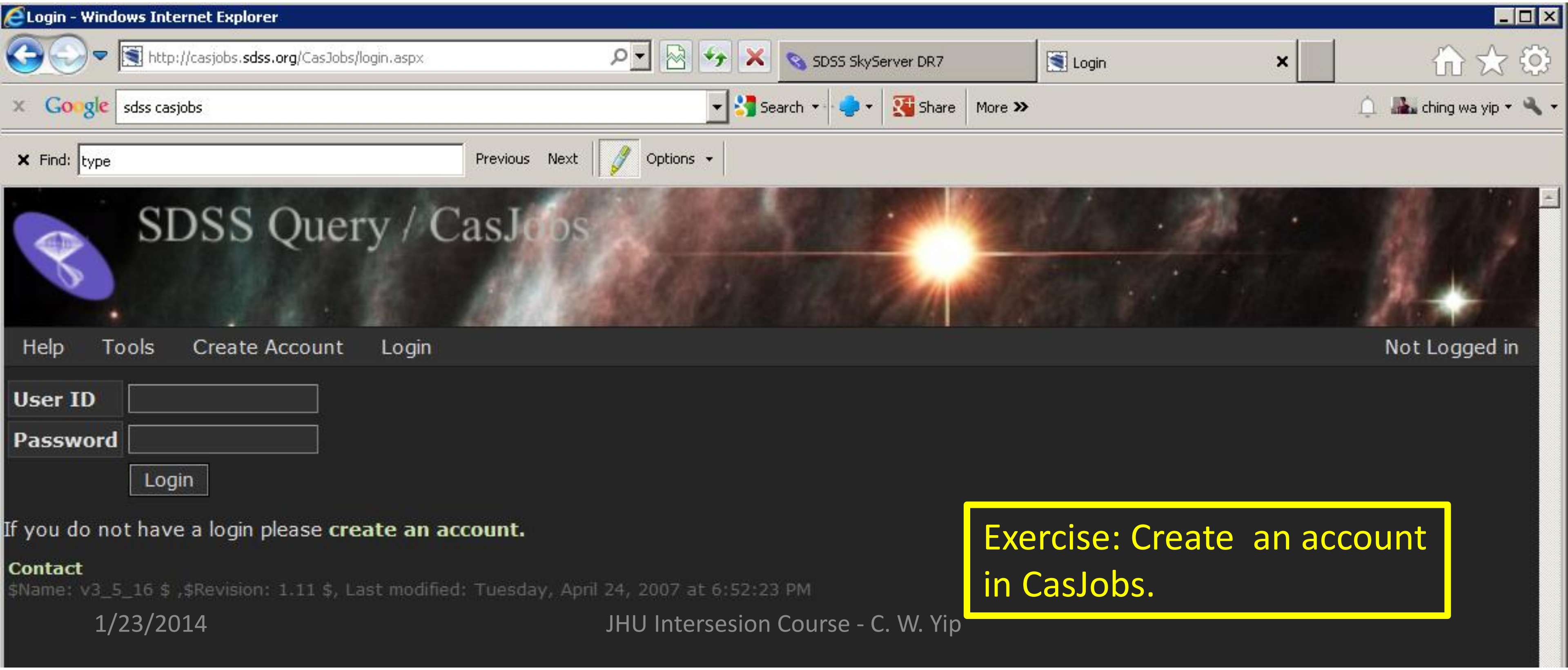
Output results to DB, if necessary



(MS SQL Server. Source: Alex Szalay)

CasJobs

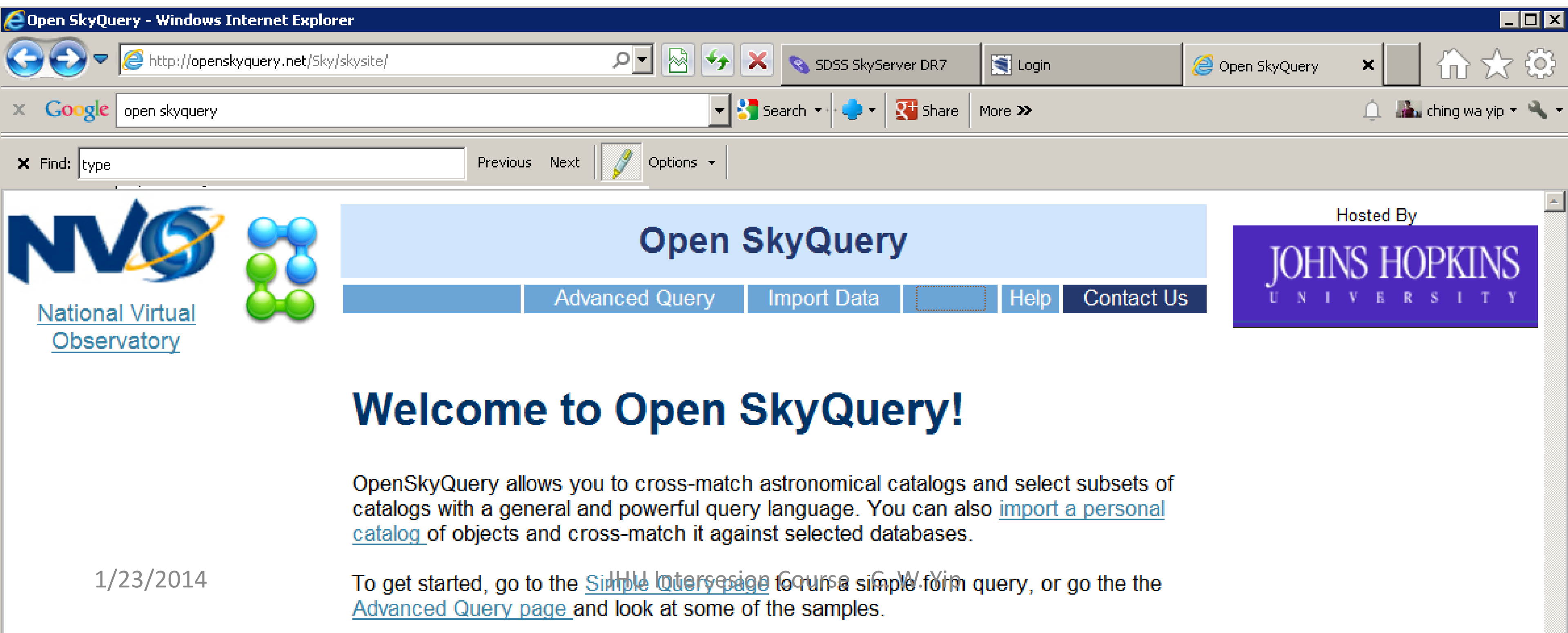
- Available for public.
- Users can register and search the public SDSS data.
- All SDSS data will become public some time after the survey completes.



Exercise: Create an account in CasJobs.

Open SkyQuery

- An ambitious platform for storing and cross-matching Catalogs from many Astronomy surveys.
- Under big overhaul and new development (2014) by L. Dobos and collaborators.

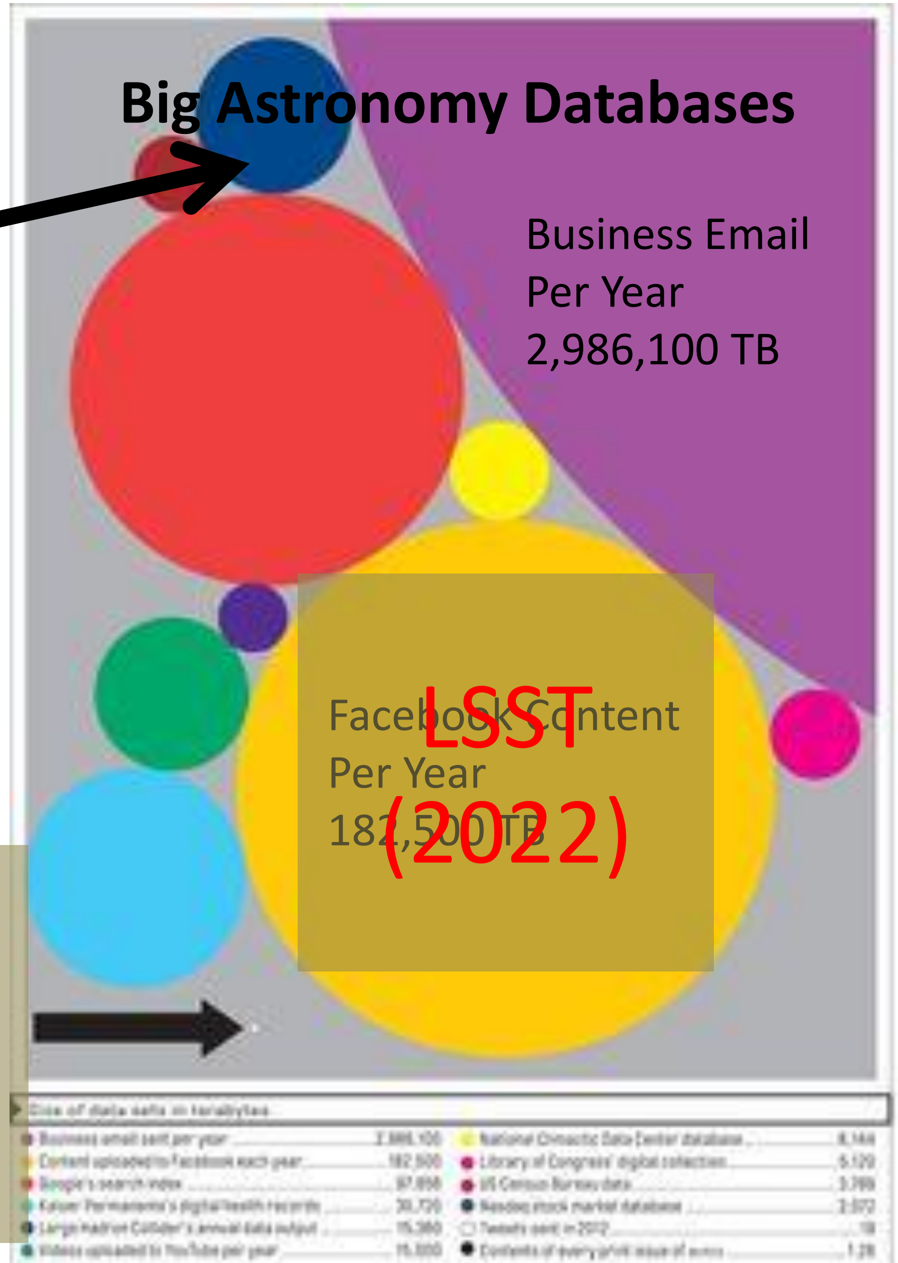


Hooking Up Database using R

- Here we use Microsoft Windows Operating System.
- Two main steps:
  - Set up user's Data Source Name (DNS) in Windows.
  - Install R library for Open Database Connectivity (RODBC).
- See class demonstration.
- The R script can be downloaded from the Course Website.

Big Astronomy Databases

Large Hadron Collider
15,360 TB



SDSS
(now)
Tweets in 2012
19 TB

1Mega = 1,000,000 = 10^6
1Giga = 10^9
1Tera = 10^{12}
1Peta = 10^{15}
1Exa = 10^{18}
1Zetta = 10^{21}

(WIRED, May 2013)